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NATIONAL DAM INSPECTION PROGRAM. LAKE PAHAGACO DAM (NDS PA-874)--ETC(U)
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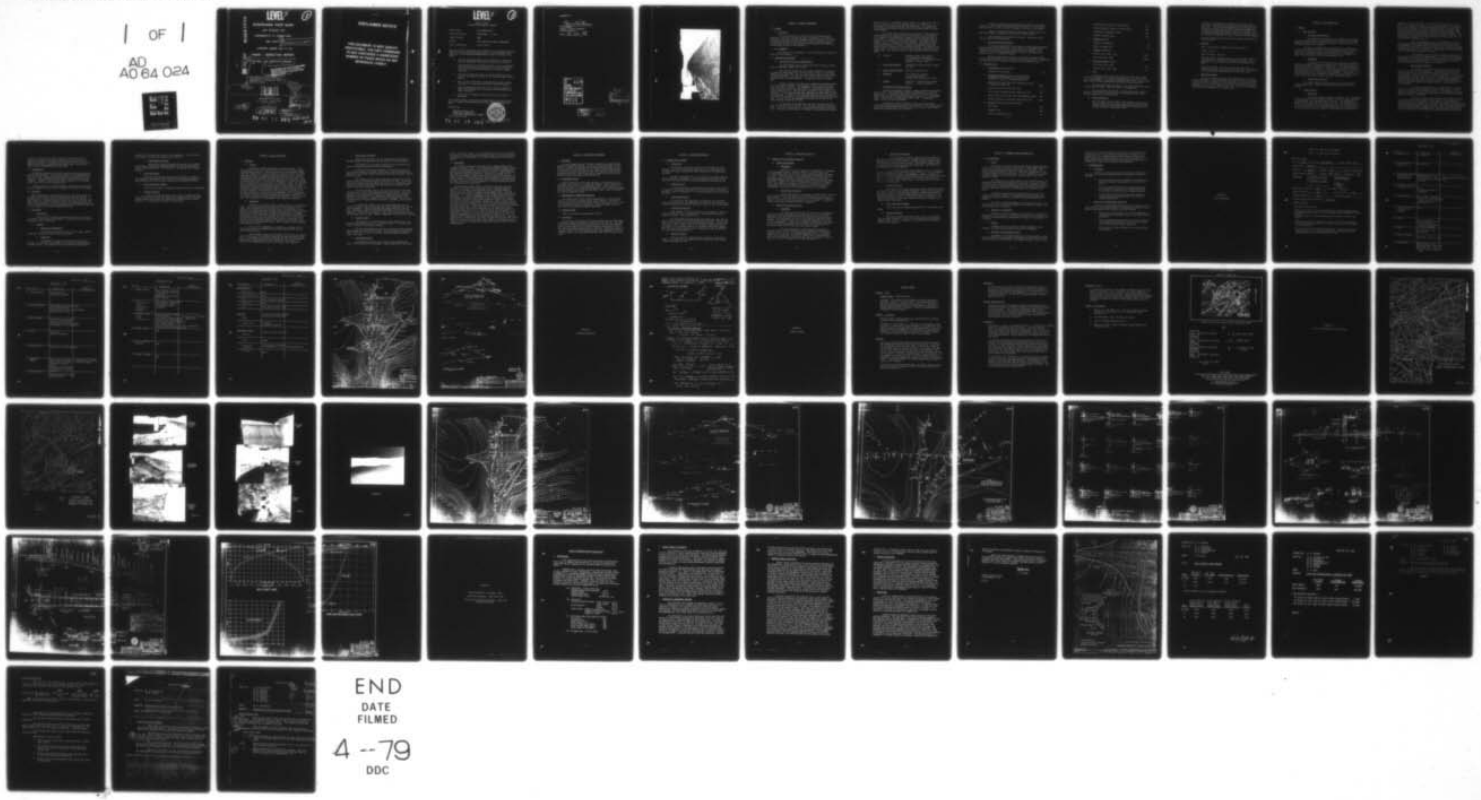

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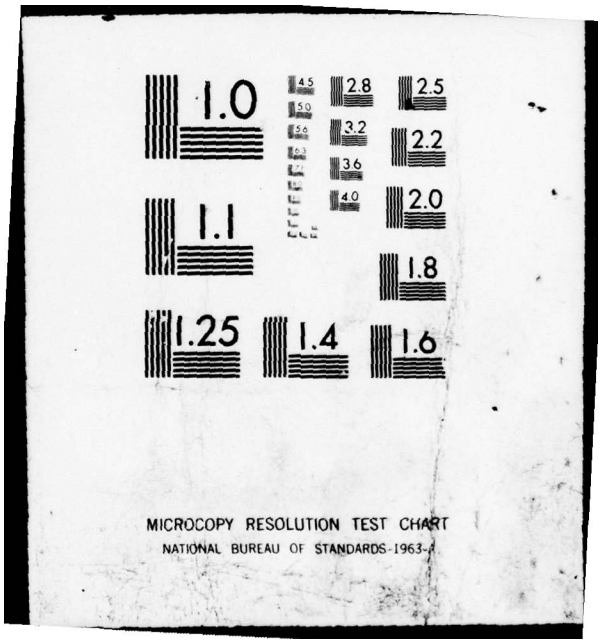
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LEVEL II

B.S. 1

SUSQUEHANNA RIVER BASIN

LAKE PAHAGACO DAM

COMMONWEALTH OF PENNSYLVANIA

YORK COUNTY

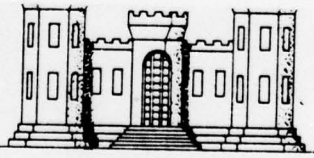
(15) DACW31-78-C-0044

INVENTORY NUMBER NDS PA. 874

PHASE I INSPECTION REPORT

(6) NATIONAL DAM INSPECTION PROGRAM.

Lake Pahagaco Dam (NDS PA-874), Susquehanna River Basin, York County, Commonwealth of Pennsylvania. Phase I Inspection Report.



Prepared For
DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland

by

BERGER ASSOCIATES, INC
CONSULTING ENGINEERS
HARRISBURG, PA

(11) JULY 1978

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LEVEL II

PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

Name of Dam:	LAKE PAHAGACO DAM
State and State No.	PENNSYLVANIA - 67-484
County Located:	YORK
Stream:	FIRST FORK BUNCH CREEK, SUSQUEHANNA
Date of Inspection:	June 20, 1978

Based on a visual inspection, past performance and available engineering data, the dam and its appurtenances appear to be in reasonably good condition. The following recommendations are made for action by the owner:

1. That the source and effect of the seepage on the downstream slope be thoroughly investigated by the owners consultant.

2. That monitoring of the seepage from the toe of the embankment and around the conduit be continued on a monthly basis and that these data be evaluated along with the slope seepage condition.

3. That the six foot weir across the outlet channel be reconstructed and monitored as part of the overall seepage investigation.

4. That a formal surveillance and downstream warning system be developed to be used during periods of high precipitation.

5. That the downstream slope cover be cut with the removal of dense brush and small trees to permit close observation and proper evaluation.

6. That a plan for regular operation of the control gates be developed.

The spillway capacity and reservoir storage capacity are sufficient to pass the Probable Maximum Flood (PMF) inflow without overtopping the dam.

Submitted By:

BERGER ASSOCIATES, INC.
HARRISBURG, PENNSYLVANIA
Contract No. DACW31-78-C-0044

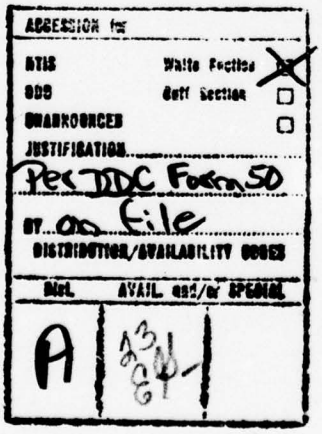
Date: July 31, 1978

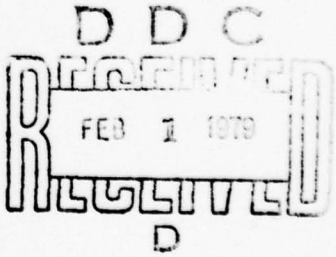
COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
HENDRIK JONGSMA
ENGINEER
No. 5557E

APPROVED BY:

G. K. WITHERS
Colonel, Corps of Engineers
District Engineer

DATE: 31 Jul 78





OVERVIEW

ABSTRACT

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

A. Authority

The Dam Inspection Act, Public Law 92-367 authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspections of dams throughout the United States. The Phase I Inspection and Report are limited to a review of available data, a visual inspection of the dam site and basic calculations to determine the hydraulic adequacy of the spillway.

B. Purpose

The purpose is to determine if the dam constitutes a hazard to human life and property.

1.2 DESCRIPTION OF PROJECT

ABSTRACT

A. Description of Dam and Appurtenances

The Lake Pahagaco dam is constructed across a Branch of Bunch Creek, in Jackson Township, York County.

The reservoir created by this dam was intended to be used as an industrial water supply for the paper mills of the P. H. Glatfelter Company, Spring Grove, Pa., and as a public water supply for the Spring Grove Water Company. The plans show the structure to be of earth construction with a concrete spillway. (Appendix D, Plates VI through XII).

The dam is about 1,127 feet total length with a maximum height of 85 feet above streambed. The embankment is about 1,065 feet long with a top width of 20 feet. The embankment is composed of impervious soil, varying from silty sand and gravel, to sandy silt and gravel, to clayey silt and gravel. The soil was taken from the side slopes of the reservoir. It was compacted by either sheepsfoot or rubber tired rollers and controlled. A trench 15 feet wide was indicated to be excavated to rock under the centerline of the embankment and backfilled with impervious soil. A grout curtain was designed to be placed in the rock by the stage grouting method under the dam.

The spillway is concrete ogee type and is located about 450 feet from the left end of the dam. It is 10 feet high and is founded on rock. A concrete curtain wall on the upstream face extends 6 feet into rock. The crest is 50 feet long. The depth of opening between abutment

walls is 10 feet. The wasteway channel tapers to a width of 32 feet at 120 feet from the crest of the spillway and is on a 8.65% slope. It then leads to a stilling basin 400 feet downstream. The channel and stilling basin are concrete and pipe drains are placed under the invert of the channel.

The intake tower is located in the vicinity of the old stream channel about 55 feet upstream from the centerline of the embankment. It is founded on rock foundation, is about 100 feet high and about 14 feet square. It connects to the embankment with a reinforced concrete bridge. The sluice gate is 48-inch in diameter. The conduit is also seated in rock. It consists of 48-inch diameter reinforced concrete culvert pipe encased in concrete. Concrete anti-seepage collars are spaced 20 feet on centers at the construction joints. The intake of the conduit starts at the end of a channel about 200 feet upstream from the intake tower. The outlet is about 325 feet downstream from the intake tower.

B.	Location:	Jackson Township, York County U.S. Quadrangle, Abbotstown, Pa. Latitude 39°-53.1', Longitude 76°-53.5' Appendix D, Plates I and II
C.	Size Classification:	Intermediate (3350 acre-feet, height 85 feet)
D.	Hazard Classification:	High (See Section 3.1.E)
E.	Ownership:	P. H. Glatfelter Company 228 South Main Street Spring Grove, Pennsylvania 17362
F.	Purpose	Initially: Industrial Water Supply Present: Private Recreation

G. Design and Construction History

The dam was designed by Gannett, Fleming, Corddry and Carpenter, Inc., in 1955. The construction contract was awarded to G.A. and F.C. Wagman, Inc. of Dallastown, Pennsylvania on May 6, 1955 and field work began on May 16, 1955. Construction progress records are in the PennDER files. Construction was completed in April, 1956. An application report is also on file with PennDER.

Construction features included a grout cap in the cutoff trench and pressure grouting to form a grout curtain in the rock foundation. Grout take was considered normal (about 0.5 bag per foot), indicating an absence of excessive voids in the bedrock.

A report on seepage through the dam was prepared by the design engineer in June, 1958, which describes their evaluation of the seepage and its effect on the dam. Refer to Appendix E for copy of this report.

Reports of seepage discharge are available from the owner up to May, 1978. Refer to Appendix E for copies of typical reports.

Annual inspections are made by the owner. Reports are available in their files through 1978.

H. Normal Operating Procedures

The dam was designed as a water supply for industrial processing. Because of objectional properties in the water, it is not suitable for this purpose and therefore, is not used as initially intended. It is operated as a private recreational facility under the supervision and control of the P. H. Glatfelter Company

Monthly inspections are made of the persistant seepage problem and an annual maintenance report is made of the entire facility. Inspections are made weekly when the water levels are below the spillway crest.

1.3 PERTINENT DATA

A. Drainage Area (square miles)

Computed for this report	2.33

B. Discharge at Dam Site (cubic feet per second)
See Appendix B for hydraulic calculations and Appendix D, Plate XII for Engineering data.

Maximum known flood, June 1972, estimated on basis of known pool Elev. 584	1,600
Warm water outlet at pool Elev. 580	44
Outlet works low-pool outlet at pool Elev. 510	100
Outlet works at pool level Elev. 580 (spillway crest)	370
Spillway capacity at pool Elev. 590 (top of dam)	6,400

C. Elevation (feet above mean sea level)

Top of dam	590
Spillway crest	580
Invert of warm water inlet	544

Upstream portal invert of outlet tunnel	508
Downstream portal invert of outlet tunnel	500
Streambed at centerline of dam	504
Maximum tailwater about	510

D. Reservoir (miles)

Length of maximum pool	1.0
Length of normal pool	0.9

E. Storage (acre-feet)

Spillway crest (Elev. 580)	3,350
Top of dam (Elev. 590)	4,990

F. Reservoir Surface (acres)

Top of dam (Elev. 590)	199
Spillway crest (Elev. 580)	137

G. Dam

A typical section of the dam is shown on Plate VII, Appendix D. The dam consists of an earthen embankment with a top width of 20 feet. The embankment is composed of compacted earth fill. The upstream slope varies and has eighteen-inch-thick dumped stone protection.

The downstream slope also varies. The entire downstream slope is topsoiled and seeded. Refer to Plate VII in Appendix D.

At the centerline of the dam, a cutoff trench with a bottom width of 15 feet has been excavated to rock foundation, and a grout curtain extends 60 feet into the rock.

H. Outlet Facilities

Water is taken into the control tower through a 72-foot long, 24-inch diameter cast iron pipe with invert elevation 544 and through a 208-foot long, 48-inch diameter reinforced concrete conduit with invert elevation of 508.

A variety of compartments and valves in the control tower provide for releasing water from either intake pipe in various flow rates. All flow is discharged through a continuation of the 48-inch conduit which is 320 feet long and terminates in an impact type energy dissipator at the toe of the dam. A 10-inch diameter siphon pipe has been added to the control tower to facilitate the release of water of the best possible quality.

A 40-foot bridge provides access to the control tower from the top of the dam.

I. Spillway

Type: Uncontrolled, standard type crest, ogee weir.

Length: 50 feet.

Crest Elevation: 580 feet.

Upstream channel: Approach channel is 50 feet wide, about 50 feet long and is 10 feet deep at normal pool stage. It is excavated in rock and there is an 8-foot apron upstream from weir.

Downstream channel: The chute is about 400 feet long. It steepens and becomes more narrow as it descends. It terminates in a stilling basin measuring about 28 feet by 80 feet.

J. Regulating Outlets

The 48-inch intake pipe enters one compartment of the control tower uncontrolled. A 48-inch diameter sluice gate controls the release of water from this compartment to the outlet pipe. A 24-inch gate valve controls the flow of water from the high level intake pipe to a second compartment, and a 12-inch diameter sluice gate is used to release water from the second compartment to the outlet pipe.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

A. Data Available

1. Hydrology and Hydraulics

The hydrologic and hydraulic data available from PennDER for this dam was limited. Area-capacity curves, rating curve for high intake and rating curve for spillway and outlet control are in the file and shown on Plate XII, Appendix D.

The report by PennDER upon the application for a permit to construct this dam states that the required spillway capacity should be 2300 cfs for a drainage area of 2.62 square miles. The design was considered satisfactory because this flow would leave a freeboard of 5 feet. This was based on a 50-foot long spillway crest.

2. Embankment

Information in the PennDER files regarding the embankment consists of typical sections and a general plan. Core boring data are also included (Refer to Appendix D, Plate IX). The boring locations are shown on Plate VIII, Appendix D. Although design criteria or stability calculations were not in the file, the file contains soil test data which were presumably used in the design of the embankment. These tests include gradation tests, laboratory permeability tests, moisture-density tests, direct and tri-axial shear tests and consolidation tests.

3. Appurtenant Structures

The design drawings indicate details of the control tower, conduit and spillway. Design criteria and design analysis were not available.

B. Design Features

1. Embankment

The design drawings show the structure to be of homogeneous earth construction with a concrete spillway. The dam is about 1127 feet in total length with a maximum height of 85 feet. The embankment is about 1065 feet long with a top width of 20 feet. The upstream slope is 1V on 2H for the first 10 feet in elevation, 1V on 2-1/2H for the next 15 feet in elevation, 1V on 3-1/2H for another 20 feet in elevation, and 1V on 4-1/2H for 25 feet in elevation. Then there is a 10 foot wide

berm where the slope continues to the heel of the dam with a 1V on 2H slope. The slopes down to the 1V on 4-1/2H was designed to be protected by a 2-foot thickness of dumped stone riprap placed on a 12-inch thick bed of filter material. The 1V on 4-1/2H slope has a 1-1/2 foot layer of dumped stone riprap on a 9-inch thick bed of filter material. The crest of the dam is protected with a 6-inch thick layer of gravel. The downstream slope was to be seeded in grass on 6 inches of top soil. The top 20 feet in elevation has a 1V on 2H slope, the next 20 feet is 1V on 2-1/2H and the remainder 1V to 3H.

Under the downstream third of the embankment is a 3-foot thick sand and gravel drain blanket which leads to a rock toe drain. The embankment is an impervious soil, varying from silty sand and gravel, to sandy silt and gravel, to clayey silt and gravel. The soil was taken from the sideslopes of the reservoir. It was compacted by either sheepsfoot or rubber tired rollers and controlled.

The foundation rock line was determined by exploration to be less than 10 feet from the ground surface. A trench 15 feet wide was indicated to be excavated to rock under the centerline of the embankment and backfilled with impervious soil. A curtain of grout was placed in the rock under the dam by the stage grouting method.

2. Appurtenant Structures

The spillway is concrete ogee type and is located about 450 feet from the left end of the dam. Its centerline makes an angle with the centerline of the embankment of about 33 degrees. It is 10 feet high and is founded on rock. A concrete curtain wall on the upstream face extends 6 feet into rock. The crest is 50 feet long. The depth of opening between abutment walls is 10 feet. The spillway discharge is rated at 2300 cubic feet per second, equivalent to a runoff of 880 cubic feet per second per square mile, under a head of 5 feet, leaving a 5 foot freeboard.

The wasteway channel tapers to a width of 32 feet at 120 feet from the crest of the spillway and is on a 8.65% slope. It then leads to a stilling basin 400 feet downstream. The channel and stilling basin are formed with concrete walls and slabs and pipe drains are placed under the invert of the channel.

The concrete water intake and sluice gate tower is located in the vicinity of the old stream channel about 55 feet upstream from the centerline of the embankment. It is founded on rock foundation, is about 100 feet high and about 14 feet square. It connects to the embankment with a reinforced concrete bridge, 5-1/2 feet wide. The sluice gate has a seating pressure 48-inch diameter gate. The conduit is also seated in rock. It consists of 48-inch diameter reinforced concrete culvert pipe

encased in a thickness of 1-foot 2-inches of reinforced concrete. Concrete anti-seepage collars are spaced 20 feet on center at the construction joints. The intake of the conduit starts at the end of a channel about 200 feet upstream from the gate house. The outlet is about 325 feet downstream from the gate house.

2.2 CONSTRUCTION

The general appearance of the dam indicates that construction was made as described above. Construction reports by the design engineer are in the file. Leakage was encountered during construction of this reservoir. Steps were taken at this time to collect and control the condition. Leakage is still present however, adjacent to the conduit outlet and at the toe drain discharge pipe.

A special report by the design engineer concluded that the leakage does not endanger the dam. Refer to Appendix E for copy of this report.

2.3 OPERATION

Normal operation was for the 48-inch sluice gate to be closed and the water taken through a 24-inch diameter cast iron pipe from the upstream face of the dam about 46 feet below the crest of the dam. The water leads into a chamber behind the sluice gate and is taken into the outlet conduit through a 12-inch sluice gate. As indicated earlier, the dam is no longer operated as a water supply source for industrial purposes. It is now operated as a private recreation facility.

2.4 EVALUATION

A. Availability

A full set of the design drawings was available in the files of PennDER. These drawings are complete. No design criteria or design calculations were in the files.

B. Adequacy

1. Hydrology and Hydraulics

The hydraulic information in the files is quite complete. Hydrologic information, however, was not included.

2. Embankment

The embankment design, as indicated on the contract drawings, is considered to be adequate if the pervious material is near the outer slopes. The seepage on the slope raises serious questions

regarding the internal flow of water in the embankment. Further studies by the owner are indicated to define this condition.

3. Appurtenant Structures

Design calculations and design criteria are not available in the files. The contract drawings indicate the type of construction and the reinforcement used. The stability of the spillway walls appears adequate.

C. Operating Records

While no formal operating records are available for review, it was reported by the operator that except for the continuous leakage, no major problems have occurred since construction was completed in 1965.

D. Post Construction Changes

There are no records of changes or modifications after construction.

E. Seismic Stability

The dam is located in Seismic Zone 1 and it is considered that the static stability is such that the dam will withstand minor earthquake induced dynamic forces under the normal safety margins used for static stability. No calculations were made to confirm this.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

A. General

The general outward appearance of the dam was good. There were no obvious signs of structural distress of the dam breast, slopes or appurtenant structures. The dam has a history of persistant seepage since its construction. Records indicate the volume of flow at several locations by means of permanently installed concrete weirs. Records also indicate some settlement problems which have been corrected. The settlement was described in the annual reports by the owner as occurring on the reservoir side of the top of the embankment. A specific location was not identified nor was the amount of settlement noted. The earliest report available that mentioned this condition was November 11, 1966. Continuous reference was made through 1974, at which time the October 30, 1974 report stated that settlement condition had been restored to its original condition. This inspection did not detect any settlement or vertical displacement on the top of the embankment. Refer to Appendix E for typical records of seepage and settlement reference. Appendix A of this report contains the visual checklist and Appendix D, Plates III, IV and V has reproductions of photographs taken during the inspection.

B. Embankment

The dam is an earthfill dam with dumped riprap on the upstream slope. The downstream slope is covered with a heavy growth of tall grass, weeds, honeysuckle and some small trees. The presence of this growth on the downstream slope increased the difficulty to detect surface distress and seepage locations. Having prior knowledge of a seepage problem at the dam, emphasized the need to seek the source locations for the seepage. Exertion of firm pressure with one's foot on the surface mat was sufficient to detect the presence of water on the slope. The results of this inspection indicate a large area of seepage across the major portion of the downstream slope. Refer to Sketch 1 and 2, Appendix A for graphic location.

The top of the embankment is covered with a blanket of 3/4" stone which serves as a roadway surface to gain access to the control tower and the spillway.

Paved drainage ditches are provided at both ends of the embankment at its abutment with natural ground and the right spillway channel wall. An additional paved ditch is provided near the left abutment were high natural ground was left in place during the construction. All ditches on the embankment were dry at the time of this inspection.

C. Appurtenant Structures

Appurtenant structures for this dam include the spillway, spillway channel, stilling basin and the intake and outlet structures.

The spillway is in excellent condition as are the walls and slab of the spillway channel and the stilling basin.

Vertical and horizontal alignment of the walls are good and the concrete surface is very good in all cases. Refer to Plate No. VI, Appendix D for drawings showing appurtenant structures and their relationship to the dam.

The intake structure houses three manual controls for valves (gates) which can manipulate the water surface in the lake. Since this lake is no longer in the operational plan of the P. H. Glatfelter plant, the gates are seldom used (the water has objectional properties with regard to the plant processing).

The main discharge pipe to the outlet structure is a 48-inch pipe which can be used as the emergency outlet for the dam. The outlet structure is a concrete impact basin with standard endwall and wings. Adjacent to each wing wall is a permanently installed concrete weir. The weirs were provided to measure the volume of seepage flow from and around the outlet structure (Refer to Sketch 1, Appendix A, for location of weirs).

An additional concrete weir is located downstream from the outlet structure at the end of an 18" pipe which originates near the toe of the embankment. This weir measures the seepage flow from the toe area. The areas around all weirs had steady flow at the time of this inspection. Flows were not measured at this time; however, some records were obtained from the owner. Refer to Appendix E for typical weir records.

D. Reservoir Area

The reservoir as indicated earlier is no longer used for the industrial processing of the P. H. Glatfelter plant. It is used exclusively for private recreational purposes.

The area surrounding the reservoir is made up of some farmland, some woodland and some well kept lawns. Several residences surround the lake. There are no records or expressed problems regarding sedimentation in the lake.

E. Downstream Channel

The downstream channel is the natural stream channel with small trees and brush on the overbanks. Several farms are in the flood

plain of this water course. It is estimated that about five residences are located in this area between the dam and the P. H. Glatfelter plant at Spring Grove, Pennsylvania. The hazard classification is, therefore, "High".

3.2 EVALUATION

The available records for this dam show an ongoing problem with seepage or leakage of water. The information regarding leakage describes the flow at weir locations at the outlet structure and presumably from the toe of the embankment below the outlet structure. These conditions were observed during the inspection. Reference to seepage from the slope of the embankment above the toe was not found in the records. The slope seepage, as noted during this inspection should be examined carefully to assess its origin and impact on the downstream slope stability. In order to do this, it will be necessary to clear the downstream slope of its high weed and brush growth.

The long term seepage, which is measured by the weirs, has been monitored by the owner over many years. Their consulting engineer, G.F.C. & C., is aware of this condition and in a special report of 6/11/58 entitled, "Study of Seepage Through Pahagaco Dam", concluded that there is no danger of piping or of any harmful effects upon the dam structure. ". . . Their recommendation was to observe and record the pool-drainage discharge relationship. Refer to Appendix E for copy of this report. Records of total flow measurement in the outlet channel over the 6 foot weir are available through July, 1960, at which time the weir was reported as "washed out". This 6-foot weir presumably measured all flow in the outlet channel including the three concrete weirs upstream from this wooden weir. (One 8-inch weir on each side of the outlet structure and one 18-inch weir downstream at the discharge point of a pipe leading from the rock toe. Refer to Sketch No.1 in Appendix A for locations). Records of the two 8-inch weirs and the 18-inch weir were reported independently in an owner's memo dated February 19, 1963. The latest record of measurement of these weirs was May 10, 1978. Refer to Appendix E for copies of the July 1960, February 1963 and May 1978 reports. Notes or records of serious concern with regard to the leakage were not found in the files nor referred to during the interview with the owner's representative.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURE

The Lake Pahagaco Dam was initially intended to be used as water supply for industrial purposes. It has been determined that the water from this lake has certain objectional properties with regard to the plant processing and therefore, it is no longer used for that purpose. It serves as a private recreational lake with operation limited to the maintaining the water level in the lake as nearly uniform as possible. Releases of water are seldom made from the dam.

4.2 MAINTENANCE OF DAM

Annual inspections by the owner are made at this dam as well as other dams owned by the P. H. Glatfelter Company. These reports notify the engineering office of the maintenance needs. Follow up action is taken as necessary. The downstream embankment slope is presently covered with tall grass, weeds, brush and some small trees. Refer to Appendix E for typical inspection report.

4.3 MAINTENANCE OF OPERATING FACILITIES

The intake control tower, located approximately 55 feet upstream from the centerline of the dam, houses three controls: one 48-inch sluice gate, one 12-inch sluice gate, and one 24-inch gate valve. There is no scheduled operation of the gates. The 48-inch gate and outlet pipe serve as the emergency drawdown capability.

4.4 WARNING SYSTEM

There is no formal warning system in effect.

4.5 EVALUATION

The operating facilities are in good condition but are seldom used. A regularly scheduled operation plan should be put into use. The downstream slope should be cleared of brush, trees and tall weed growth so that any slope seepage can be readily observed, especially in view of the other persistent seepage history of this dam. Additional studies to carefully examine and to determine the source and magnitude of the wet condition high on the downstream embankment slope should be made by the owner.

SECTION 5 - HYDROLOGY/HYDRAULICS

5.1 EVALUATION OF FEATURES

A. Design Data

The hydraulic information available from PennDER was quite complete. The file contained area-capacity curves, rating curves for the spillway and the outlet works, and a complete set of construction drawings.

Neither the PennDER files or the owner nor the design engineer had any hydrologic information. A single exception was a note in the files that the June 1972 flood caused a maximum pool elevation of 584.

B. Experience Data

In the period that the dam has been in existence, from 1958 to the present, the maximum flood was that of June 22, 1972, when the flow was about 1,600 cfs (Appendix B). The spillway passed that flood without distress.

C. Visual Observations

On the date of the inspection, no conditions were observed that would indicate that the appurtenant structures of the dam could not operate satisfactorily during a flood event, until the dam is overtopped.

D. Overtopping Potential

This dam has a size classification of "Intermediate" (85 feet high and 4,990 acre-feet of storage) and a hazard potential classification of "High". (See Section 3.1.e).

The Recommended Spillway Design Flood (SDF) for a dam with the above classifications is the Probable Maximum Flood (PMF). The PMF peak flow for this site is 8,160 cfs and the spillway capacity at top of dam level (Elev. 590) is about 6,400 cfs or 78 percent of PMF peak inflow. An estimate of the storage effect of the reservoir shows Lake Pahagaco does have the storage available that is necessary to pass the PMF without overtopping (see Appendix B).

E. Spillway Adequacy

With the reservoir storage capacity available, the spillway capacity is considered to be adequate as the project will pass the PMF without overtopping the dam.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

A. Visual Observations

1. Embankment

There are no visual indications of settlement or sloughing of the embankment slopes. There is, however, a sizable area of the downstream slope which was found to be wet during this inspection (June 20, 1978). The heavy growth on this slope makes it difficult to define the limits of this condition. Considerable records have been kept regarding leakage at the outlet structure and from the toe of the slope, up to 1978. Reference to slope seepage, however, has not been found in any of the available information. Removal of the growth on the downstream slope and further examination and study of this condition is recommended. The wet area on the downstream slope is of concern.

2. Appurtenant Structures

Visual inspection of the spillway, spillway chute, stilling basin, inlet structure and outlet structure indicates that all are in good condition. Since the dam is not a part of the industrial operation, there is no formal operational procedure for this facility. A plan for regular operation of the gates should be considered.

B. Design and Construction Data

1. Embankment

The construction plans show the details of the embankment. A grout curtain is indicated at the foundation of the cutoff trench. Beginning at 100 feet downstream from the centerline of the dam and at the base of the embankment is a three foot thick sand and gravel drain blanket. This blanket extends in the downstream direction to the rock toe of the embankment. Eight inch toe drains are indicated at the right and left downstream embankment slope abutments and an 18-inch V.C.P. drain pipe leads from the rock toe to the outlet channel.

The main embankment is rolled impervious material of selected mixture of clay, sand, and gravel increasing in permeability toward the outer slopes. The upstream embankment slope is a variable slope and is covered with 18 inches of dumped stone. The downstream slope is also variable and is covered with topsoil and seeded. Refer to Plate Nos. VI and VII, Appendix D for plan and sections.

2. Appurtenant Structures

The spillway is a concrete ogee type and is founded on rock with a concrete curtain wall on the upstream face extending 6 feet into the rock. The crest is 50 feet in length between abutment walls. The walls extend 10 feet above the crest. The wasteway channel tapers and leads to the stilling basin 400 feet downstream. All features of the spillway are in good condition.

The intake structure, also founded on rock, is a concrete housing containing the outlet control gates and valve. It is accessible from a footbridge connected to the embankment. General condition is very good. A 48-inch diameter discharge pipe leads to the outlet structure which is a concrete impact basin type. The outlet is about 325 feet downstream from the intake control tower. The condition of the outlet facilities is also good.

C. Operating Records

While there are no formal operating records, monthly inspections are made by the owner and reports are prepared. Weirs have been constructed at the ends of three discharge pipes and readings are recorded in the monthly reports. Detailed annual reports are also prepared in the maintenance program of the P. H. Glatfelter Company. According to the owner's representative, when water levels are below the spillway crest, inspections are made weekly.

D. Post Construction Changes

There have been no reported modifications to the original dam design.

E. Seismic Stability

This dam is located in Seismic Zone 1 and it is considered that the static stability is sufficient to withstand minor earthquake induced dynamic forces. No studies or calculations have been made to confirm this assumption.

SECTION 7 - ASSESSMENT AND RECOMMENDATIONS

7.1 DAM ASSESSMENT

A. Safety

The review of the files indicates an ongoing leakage condition at the outlet structure and from the toe drain. Considerable amount of records are available quantifying these flows over the years. The owners consulting engineer's opinion is that these leakages do not pose a serious problem to the dam structure. Refer to Appendix E for typical records of seepage flows as reported by the owner and a copy of the engineer's report.

The inspection of the dam revealed a wet condition high on the downstream slope indicating seepage across the area. The heavy growth of weeds on the downstream slope makes it difficult to define the limits of this condition. Additional investigations to establish the source of this wet condition as well as its extent should be initiated by the owner.

Calculations indicate that this dam and reservoir have the storage and spillway capacity for accommodating the PMF without overtopping of the dam and they are, therefore, considered hydraulically adequate.

The overall outward appearance of this facility is good. The only exceptions are the apparent seepage on the downstream slope and the heavy ground cover in this area.

B. Adequacy of Information

Sufficient hydraulic information is available to evaluate the performance of the facility. Sufficient information is not available to evaluate the downstream slope seepage and its impact on the stability of the slope.

C. Urgency

Although there is no evidence of slope sloughage or other distress, the slope seepage condition should be investigated.

D. Necessity for Additional Studies

The seepage on the downstream slope of this dam points out the need for additional investigation to determine its source and its effect on the stability of the structure. The seepage records at the two weirs

at the outlet structure and the one at the end of the discharge pipe leading from the rock toe should be continued on a monthly basis. Comparisons of the readings should be made with past records by the owner's consultant. Reconstruction of the 6-foot weir across the outlet channel downstream of the three weirs mentioned should also be considered as a part of the additional investigations.

7.2 RECOMMENDATIONS

A. Facilities

In order to assure the continued satisfactory operation of this dam, the following recommendations are presented for action by the owner:

1. The the source and effect of seepage on the downstream slope be thoroughly investigated by the owner's consultant.

2. That the seepage from the toe and around the conduit be continued to be monitored on a monthly basis and be evaluated along with the slope seepage condition.

3. That the six foot weir across the outlet channel be reconstructed and monitored as part of the overall seepage investigation.

B. Operation and Maintenance Procedures

This dam is inspected monthly and with the exception of the heavy cover on the downstream slope, the maintenance of the dam is good. Special recommendations for action by the owner include:

1. That a plan for surveillance and a formal downstream warning system be developed for use in the event of high discharges.

2. That the downstream slope cover be cut with the removal of the dense brush and small trees in order to permit close observations and proper evaluation.

3. That a plan for regular operation of the control gates be developed.

APPENDIX A

VISUAL INSPECTION

CHECK LIST - DAM INSPECTION PROGRAM

PHASE I - VISUAL INSPECTION REPORT

NAD NO. 874

PA. ID # 67-484 NAME OF DAM Lake Pahagaco HAZARD CATEGORY High

TYPE OF DAM: Earthfill

LOCATION: Jackson TOWNSHIP York COUNTY, PENNSYLVANIA

INSPECTION DATE 6/20/78 WEATHER Sunny - Warm TEMPERATURE 80's

INSPECTORS: H. Jongsma, R. Houseal — P.H.Glatfelter Co.
Dr. Jon F. Myers

A. Bartlett, R. Steacy

D.E.R.
P. Gardosik
A. Hanna

NORMAL POOL ELEVATION: 580 AT TIME OF INSPECTION:

BREAST ELEVATION: 590 POOL ELEVATION: 580

SPILLWAY ELEVATION: 580 TAILWATER ELEVATION:

MAXIMUM RECORDED POOL ELEVATION: No record

GENERAL COMMENTS:

Flow barely over spillway.

Seepage over extensive area of downstream slope beginning approximately 65' (slope distance) from the top of the dam. Refer to Sketches #1 and #2 attached.

Downstream slope is covered with high grass and brush also some small trees.

Three concrete weirs are located in the area of the outlet structure. Another deteriorated wooden weir is located across the outlet channel. It is not operable.

Tall grass and brush on downstream slope made it difficult to observe slope condition. Wet areas were detected by carefully walking and pressing firmly onto the slope with one's foot.

VISUAL INSPECTION

EMBANKMENT	OBSERVATIONS	REMARKS & RECOMMENDATIONS
A. SURFACE CRACKS	None evident	
B. UNUSUAL MOVEMENT BEYOND TOE	None evident	
C. SLOUGHING OR EROSION OF EMBANKMENT OR ABUTMENT SLOPES	Upstream slope - none Downstream slope - none detectable due to growth on slope.	Remove trees and brush and cut weeds.
D. VERTICAL & HORIZONTAL ALIGNMENT OF CREST	Good No apparent movement or settlement.	
E. RIPRAP FAILURES	None evident. Upstream slope is covered with dumped rip rap rock up to 24" estimated in size.	
F. JUNCTION EMBANKMENT & ABUTMENT OR SPILLWAY	Good	
G. SEEPAGE	Most of downstream slope (Refer to general comments) and Sketches #1 and #2 attached	
H. DRAINS	18" pipe below outlet. Steady flow.	
J. GAGES & RECORDER	Float gage in intake tower.	
K. COVER(GROWTH)	Stone roadway on top. Upstream slope - dumped rock. Downstream slope - heavy weeds, brush and some small trees.	

DAM NO. NAD 874

VISUAL INSPECTION

OUTLET WORKS	OBSERVATIONS	REMARKS & RECOMMENDATIONS
A. INTAKE STRUCTURE	Concrete tower in excellent condition.	
B. OUTLET STRUCTURE	Impact basin with concrete walls & 48" diameter pipe. Concrete weirs at end of each wingwall. Steady flow both sides.	
C. OUTLET CHANNEL	Brush & light trees along channel. Stone bottom. Large wooden weir across channel - deteriorated - out of operation	
D. GATES	Three gates (Refer to drawings)	
E. EMERGENCY GATE	From tower - 48" pipe and gate.	
F. OPERATION & CONTROL	Weekly visit to measure water level in the lake. Float gage in control tower. The water from this lake is not used in the paper process.	No indication of scheduled operation of gates.
G. BRIDGE (ACCESS)	Concrete bridge with railing - good condition.	

DAM NO. NAD 874

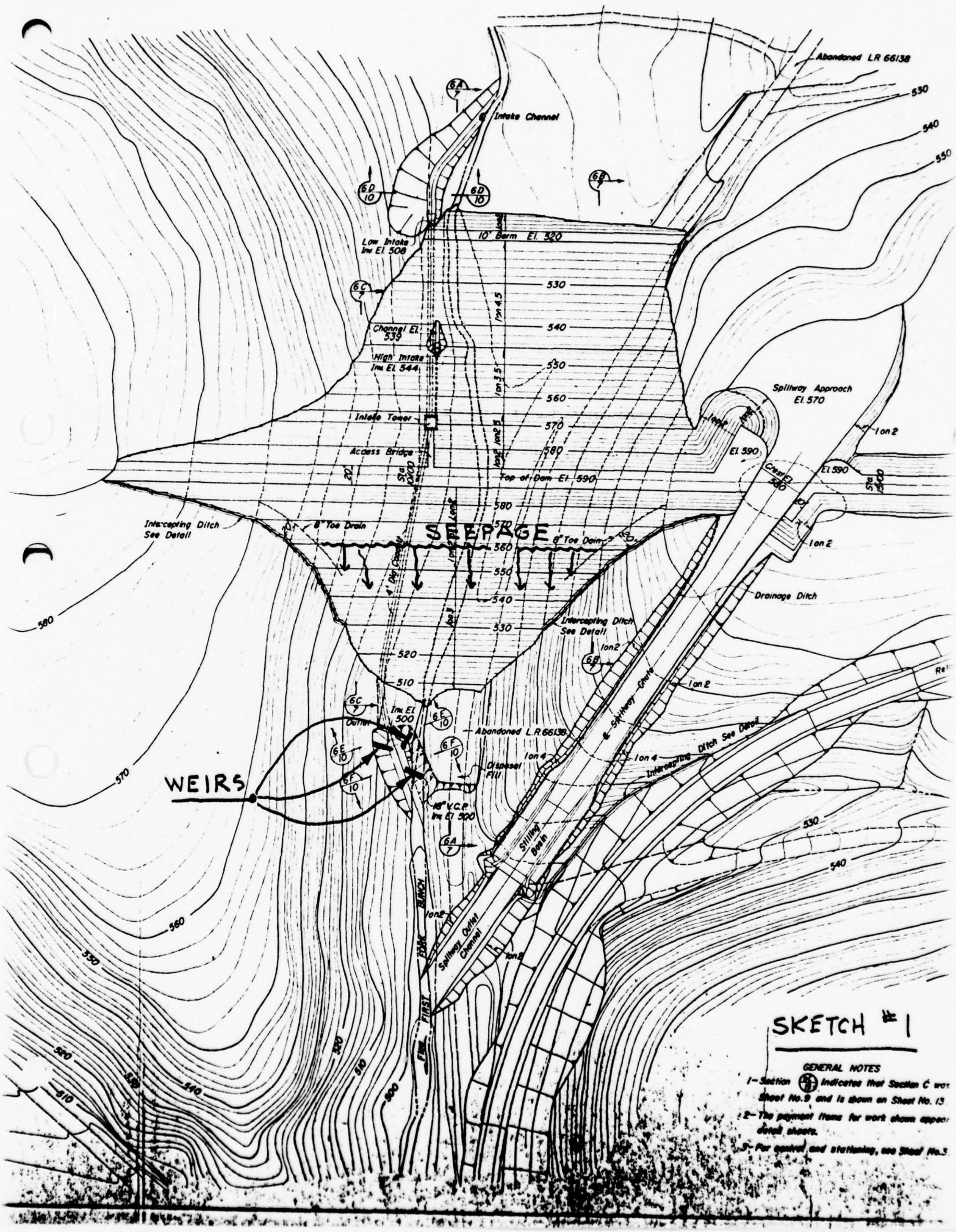
VISUAL INSPECTION

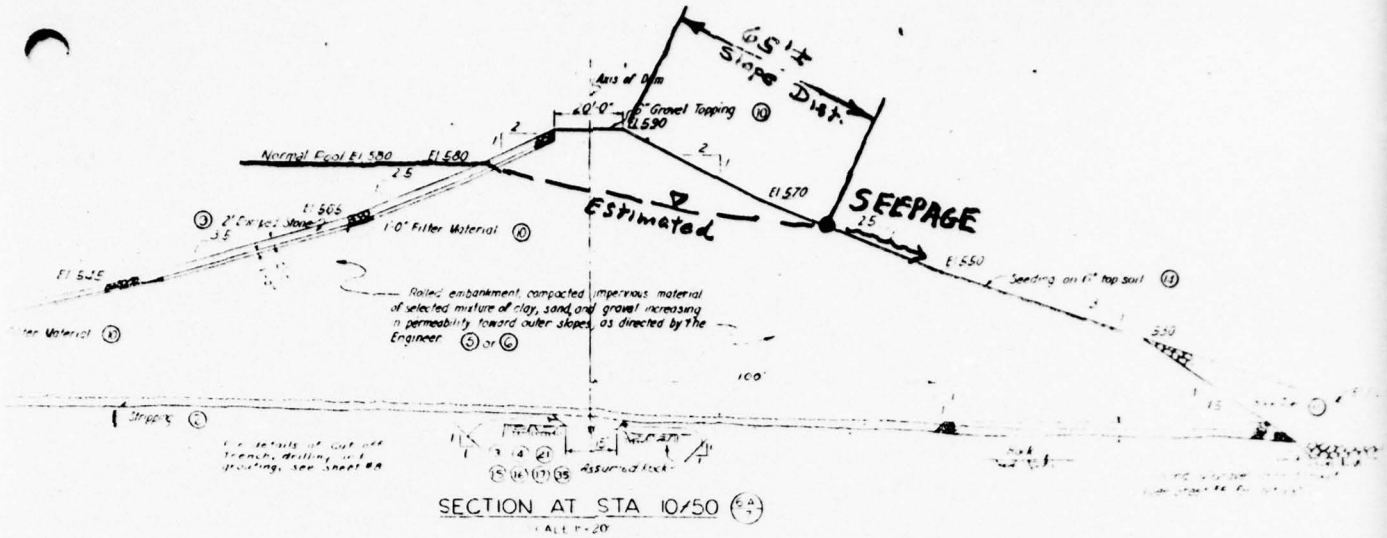
SPILLWAY	OBSERVATIONS	REMARKS & RECOMMENDATIONS
A. APPROACH CHANNEL	Curved concrete walls to ogee spillway - directly from lake. Railing on top of walls. Good condition.	
B. WEIR: Crest Condition Cracks Deterioration Foundation Abutments	Ogee section. Safety cable strung across spillway. All concrete in good condition.	
C. DISCHARGE CHANNEL Lining Cracks Stilling Basin	Concrete channel leading to stilling basin. All concrete in good condition. Concrete paved drainage ditch behind right wall on embankment - dry - good condition. Concrete paved ditch on left side - discharging water at end below stilling basin.	Rock exposed on left side behind wall.
D. BRIDGE & PIERS	None	
E. GATES & OPERATION EQUIPMENT	None	
F. CONTROL & HISTORY	None	

DAM NO. NAD 874

VISUAL INSPECTION

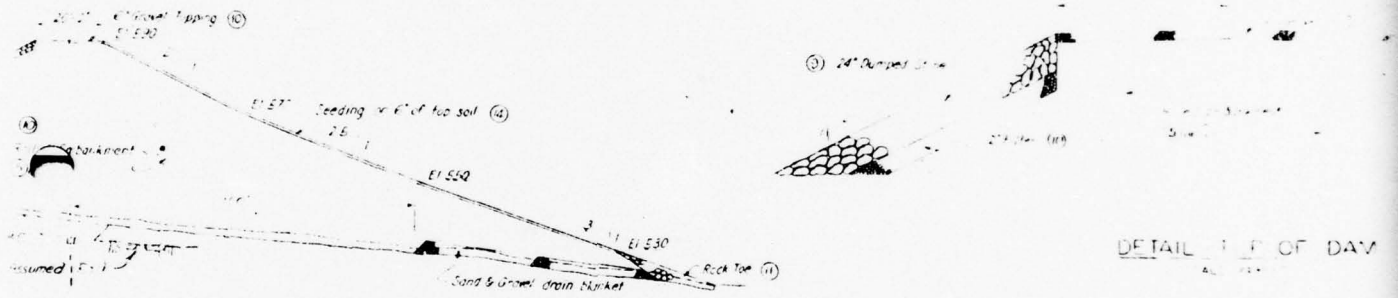
MISCELLANEOUS	OBSERVATIONS	REMARKS & RECOMMENDATIONS
INSTRUMENTATION		
Monumentation	None	
Observation Wells	None	
Weirs	Three to measure seepage	
Piezometers	None	
Other	Float gage in control tower	
RESERVOIR		
Slopes	Some each of farmland, wooded areas and well kept lawns.	
Sedimentation	No record. No problems indicated	
DOWNSTREAM CHANNEL		
Condition	Choked with brush and trees.	
Slopes	Stable	
Approximate Population	5-6 farm homes and farmland P.H. Gladfelter - 3 1/2 - 4 miles donwstrean	
No. Homes	Above	


SKETCH #1
WEIRS
SEEPAGE
Abandoned LR 66138
Intake Channel
Low Intake Inv. El. 508
10' Berm El. 520
Channel El. 539
High Intake Inv. El. 544
Intake Tower
Access Bridge
Top of Dam El. 590
Spillway Approach El. 570
El. 590
Crest El. 580
8" Toe Drain
Intercepting Ditch See Detail
Drainage Ditch
Abandoned L.R. 66138
Disposal Fill
Outlet
Inv. El. 500
18" V.C.P. Inv. El. 500
Stilling Basin
Spillway Outlet Channel
Spillway Chute
Intercepting Ditch See Detail
GENERAL NOTES
1- Section indicates that Section C was Sheet No. 9 and is shown on Sheet No. 13
2- The payment items for work shown appear detail sheets.
3- For control and stationing, see Sheet No. 3



SECTION AT STA 10+50 (6A/7)

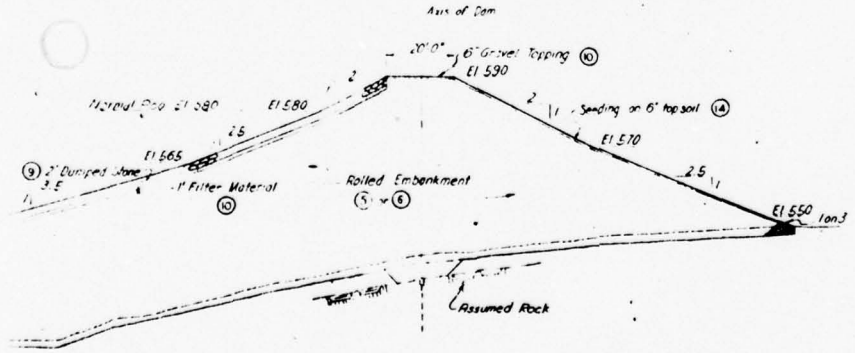
SCALE 1"=20'



DETAIL OF DAM

N AT STA 9+50 (6/7)

SCALE 1"=20'



SECTION AT STA 12+00 (6B/7)

SCALE 1"=20'

SKETCH #2

GENERAL NOTES

1- Section (6B/7) indicates that Section C was taken on Sheet No. 9 and is shown on Sheet No 13.
2- Numbers in circles indicates item numbers under which payment will be made.
3- All dimensions and existing conditions shall be checked and verified by the contractor at the site.
4- All stationing along base line of dam has no suffix.

REVISIONS			
NO.	DESCRIPTION	DATE	BY

APPENDIX B

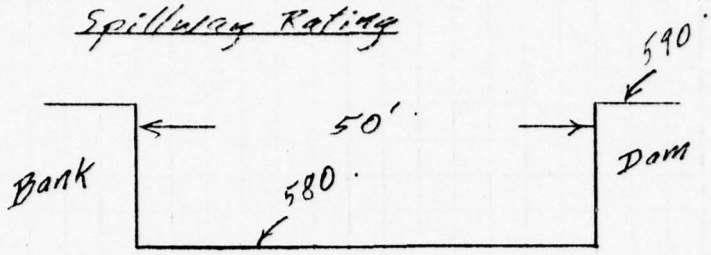
HYDROLOGY/HYDRAULICS

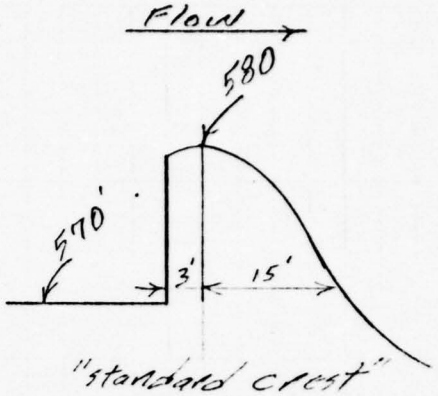
PROJECT Dam Investigations SHEET NO. 1 OF 1

SUBJECT Lake Pahagaco Dam ID No. 874

COMPUTED BY RES DATE 7-3-'78 CHECKED BY JJPJr 7-6-'78

Spillway Rating





Elev. 590

$Q = C L H^{3/2}$

$= 4.10 \times 50 \times (10)^{3/2}$

$= 6,480$ cfs

Design Engineer's rating.

$= 6,400$ cfs

Use design engineer's rating.

"standard crest"
Use "C" = 3.8
for H = 5 ft.
Ref. Brater + King
6th Ed. P. 5-28

Maximum Known Flood

Note in file indicates June 1972 flood reached pool elev. of 584

$= 1,600$ cfs from rating.

PMF No suitable PMF data for a nearby site was available so the Baltimore Dist. C. of E. standard curves will be used.

Region No. 1, Susq. R. Basin Drain. Area 2.33

PMF $= 3,500$ cfs/sq. mi.

$= 2.33 \times 3,500 = 8,160$ cfs.

$\frac{\text{Max. Spillway Q}}{\text{Peak inflow}} = \frac{6,400}{8,160} = 0.78$

$\frac{\text{Req. Resv. Storage}}{\text{Vol of Inflow}} = 0.22$ From short cut flood routing method furnished by C. of E.

26" inflow $= 53.33 \times 26 \times 2.33 = 3230$ ac. ft.

Req. Resv. Storage $= 0.22 \times 3230 = 710$ ac. ft.

Available storage $= 4990 - 3350 = 1,640$ ac. ft.

Lake Pahagaco has the storage to pass the PMF.

APPENDIX C

GEOLOGIC REPORT

GEOLOGIC REPORT

Bedrock - Dam

Formation Name: Harpers Phyllite.

Lithology: Gray-green, finely crystalline phyllite composed of muscovite, chlorite, albite and quartz. Has interbeds of gray phyllitic quartzite, especially in its upper part. Phyllite is a medium grade metamorphic rock with strong slaty cleavage which obscures bedding in most exposures. At least two generations of cleavage are usually present.

Bedrock - Reservoir

Formation Names: Chickies Quartzite, Harpers Phyllite, Antietam Quartzite and Vintage Dolomite.

Lithologies: The Chickies is a light gray to white massive bedded quartzite, with some black slate interbeds in its upper part. The Harpers Phyllite, described above, grades upward into the Antietam Quartzite, which is composed of gray quartzite with gray phyllite interbeds. The Vintage Dolomite is mostly a blue gray, dolomite with irregular lumps, or knots of silty, shaly dolomite.

Structure

The rocks of southern York County have been extensively deformed and metamorphosed several times in their long history. According to the mapping of Stose and Jonas (Ref. 1) the dam is located on the southeast limb of a faulted anticline. The strike of the beds here is about N60°E and the dip is steep to the southeast. The axis of the fold, cleavage and faults all strike the same direction as the bedding. There are no mapped faults at the dam itself. Two are mapped in the reservoir area. The first, nearest the dam is apparently a steeply dipping (more than 45°) branch of the Gnatstown thrust. The Gnatstown thrust is a folded thrust which here dips gently to the southeast.

No data on rock jointing are available. Air photo fracture traces have the following orientations: N80°-85°W, N60°W, N50°W, N25°-30°W, N10°W and N15°E.

Overburden

The overburden in the area is from three to twenty feet thick. It consists of weathered phyllite, sand, clay and quartz fragments. The contact with bedrock is gradational, the top ten feet, or more, of bedrock being more, or less, weathered. The stream valley alluvium was thin, two to four feet of sand and gravel overlying hard gray phyllite.

Aquifer Characteristics

The Harpers Phyllite is composed of essentially impermeable rock. Ground water movemet is through fractures, in this case, joints and fracture cleavage. The fractures are generally tight, except in the weathered zone. The Chickies and Antietam Quartzites are similar in their water bearing characteristics. The Vintage Dolomite is a carbonate rock, and water movement is along fractures and bedding planes enlarged by solution.

Discussion

This dam has a history of seepage (see Ref.4). According to Mr. Hooke's report, the seepage was from two sources. An 18-inch diameter drain was installed near the center of the rock toe of the dam to drain out seepage water through the embankment. This is in the old stream bed, composed of sand and gravel, and the most permeable of the overburden material. About one-half of the seepage was through this drain.

A spring was encountered during the excavation (in rock) for the outlet conduit, apparently just downstream from the crestline of the dam. An 8-inch diameter drain pipe was placed on each side of the outlet to drain this flow. Before construction of the embankment the pipe on the right side of the conduit flowed nearly half full, while the other carried little water. On the upstream side of the dam, two rows of grout holes were pressure grouted and no further water was encountered.

As the reservoir was filled above the 570 feet elevation, seepage in the 8-inch pipe on the left hand side increased greatly while seepage on the right hand side decreased. The seepage water was clear, and while the loss through the three pipes totaled 1.2 mgd, it was decided that there was no immediate threat to the dam. The flows were monitored for several years.

Discussion (Cont'd)

It is apparent that much of the seepage is through fractures in the bedrock. Although it was not evident in the core borings, the outlet conduit is close to a fracture trace, which controlled the course of the stream at the dam site. Cleavage (parallel to bedding) intersects this fracture trace at nearly right angles. The rock is insoluble and there is no chance of widening of the fracture by solution.

Sources of Information

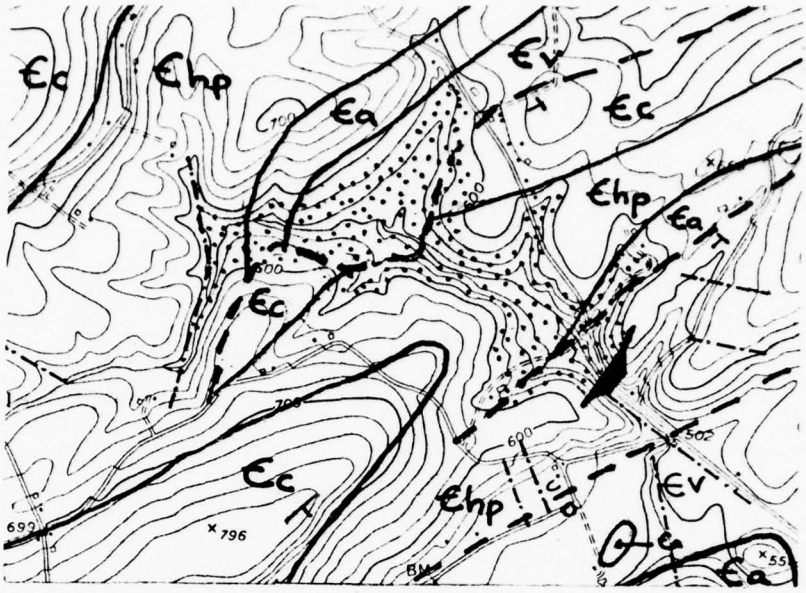
1. Stose, G.W., and Jonas, A.I., 1939 "The Geology and Mineral Resources of York County, Pa." Pa. Geological Survey. Bulletin C-67.

2. Air Photographs, scale 1:24,000, dated 1968.

3. Logs of Foundation Borings on File.

4. Hooke, A.C. 1958. "Study of Seepage through Pahagaco Dam". Memorandum in file.

LAKE PaHaGaCo DAM



(geology from Pa. Geol. Survey Bulletin C-67)

KEY

ϵ_v Vintage Dolomite	———$\frac{U}{D}$ high angle fault
ϵ_a Antietam Quartzite	——I— thrust fault
ϵ_{hp} Harpers Phyllite	⊢ air photo strike and dip
ϵ_c Chickies Quartzite	
- - - - - air photo fracture trace	

SCALE 1:24000

1 ½ 0 1 MILE

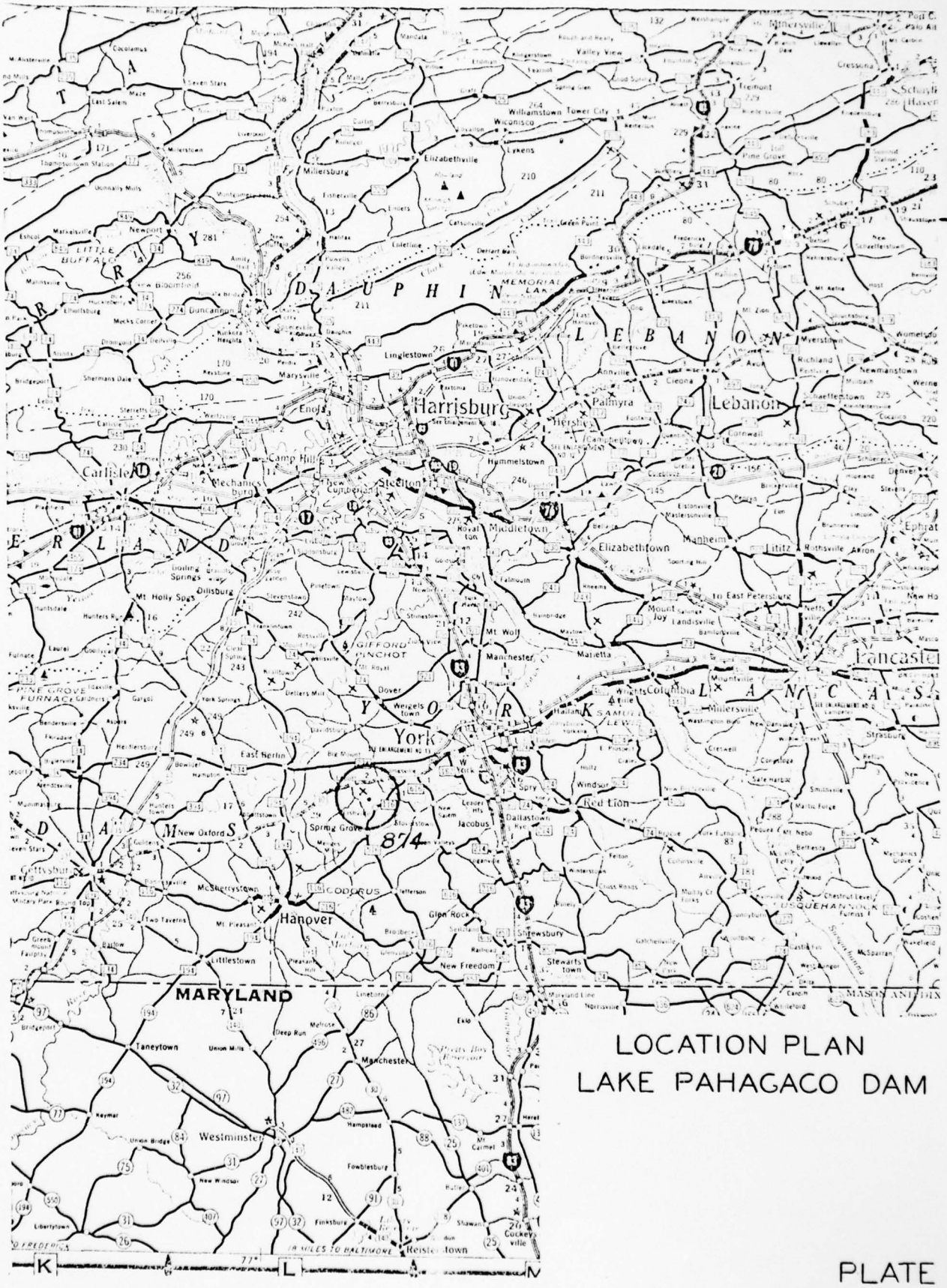
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

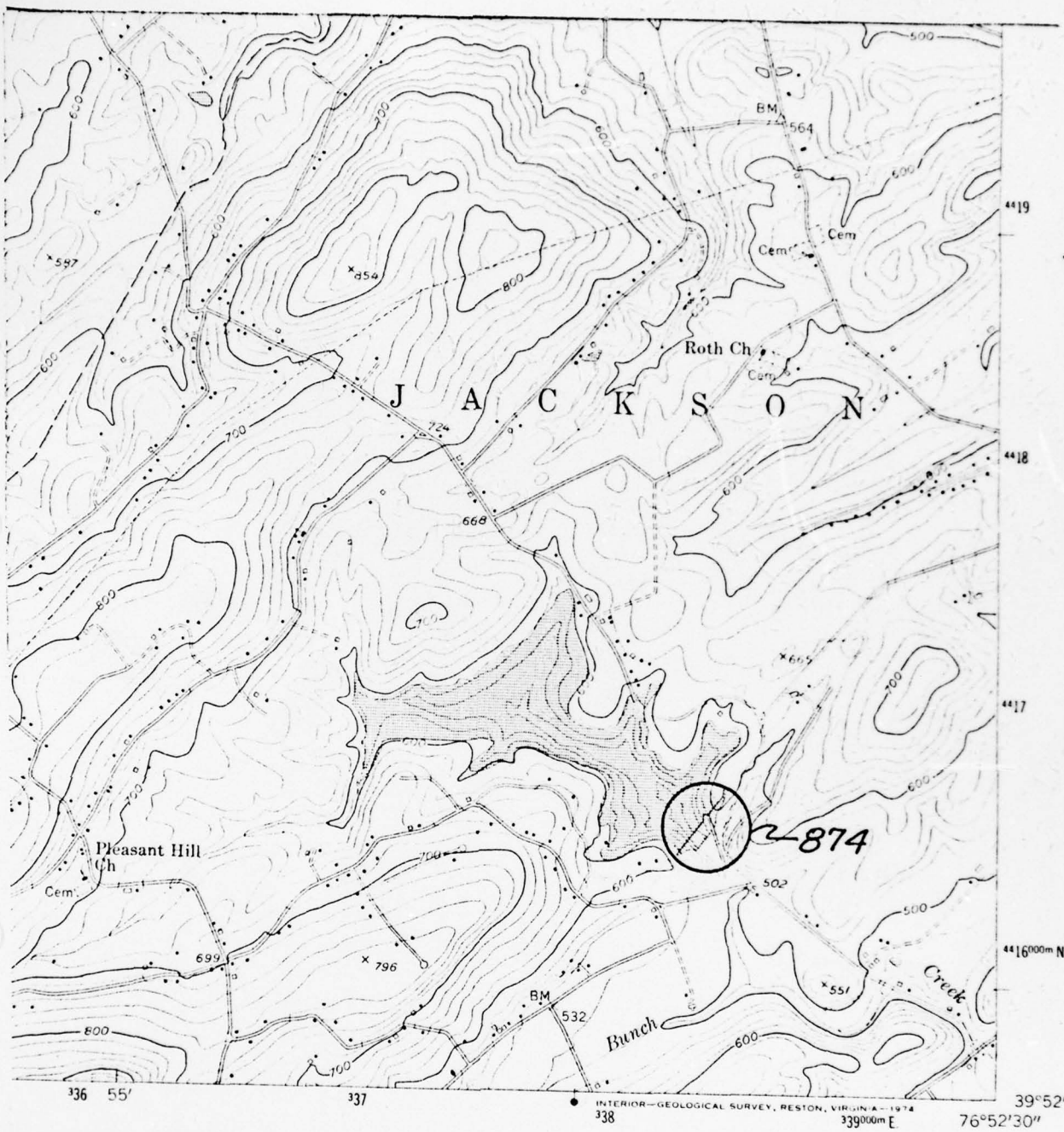
APPENDIX D

LOCATION, PHOTOGRAPHS & DESIGN DRAWINGS



LOCATION PLAN
LAKE PAHAGACO DAM

PLATE I



Heavy-dut

Medium-c

VICINITY MAP
U.S.G.S. QUADRANT
ABBOTTSTOWN PA.

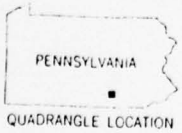
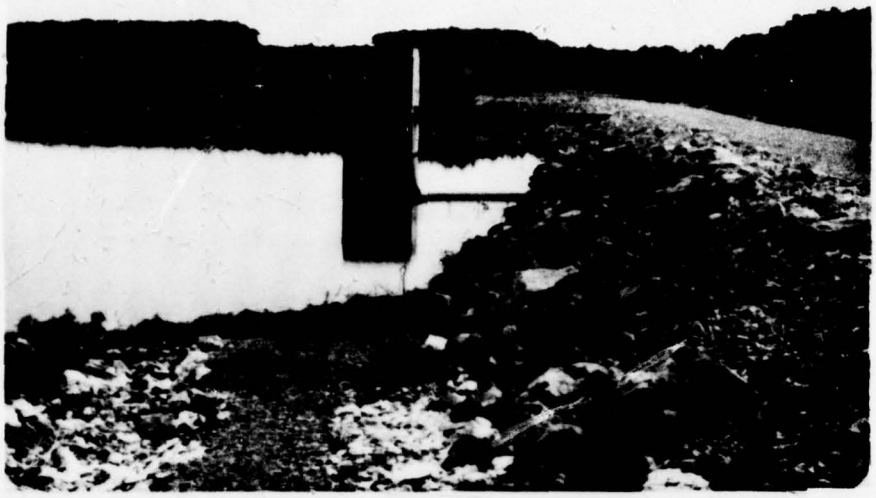


PLATE II

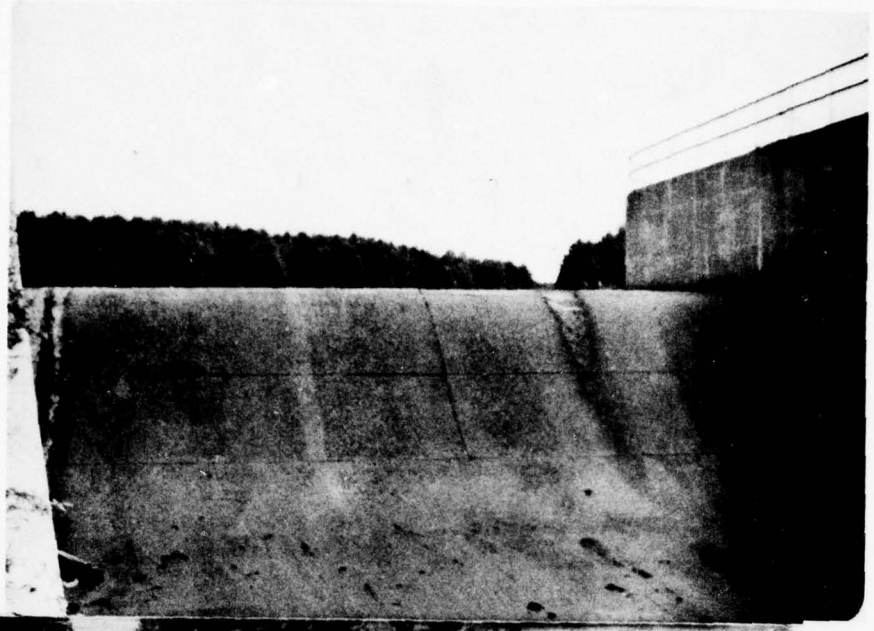


OVERVIEW
UPSTREAM
SLOPE

DOWNSTREAM
EMBANKMENT

SPILLWAY &
CONDUIT
OUTLET

PLATE III

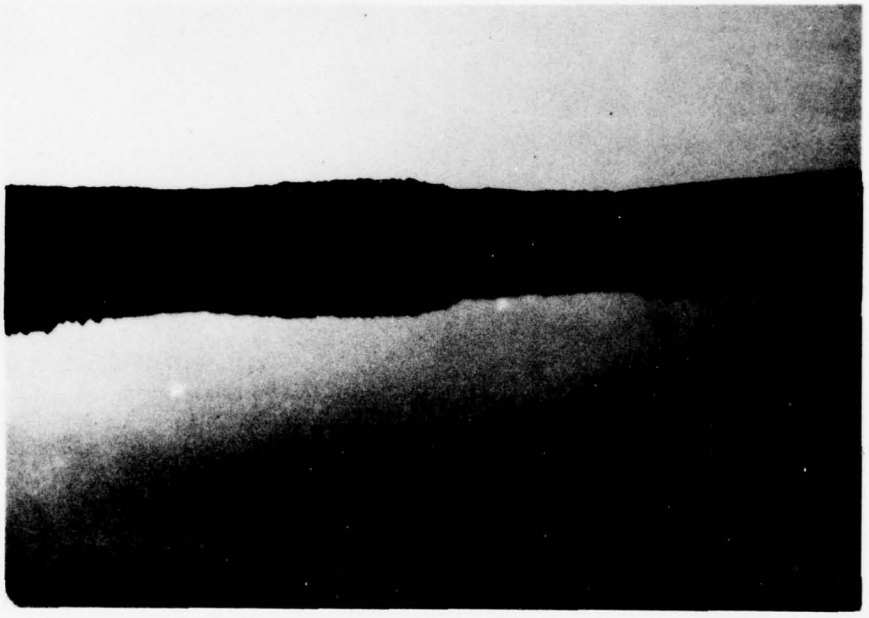


SPILLWAY
WEIR

SPILLWAY
CHUTE

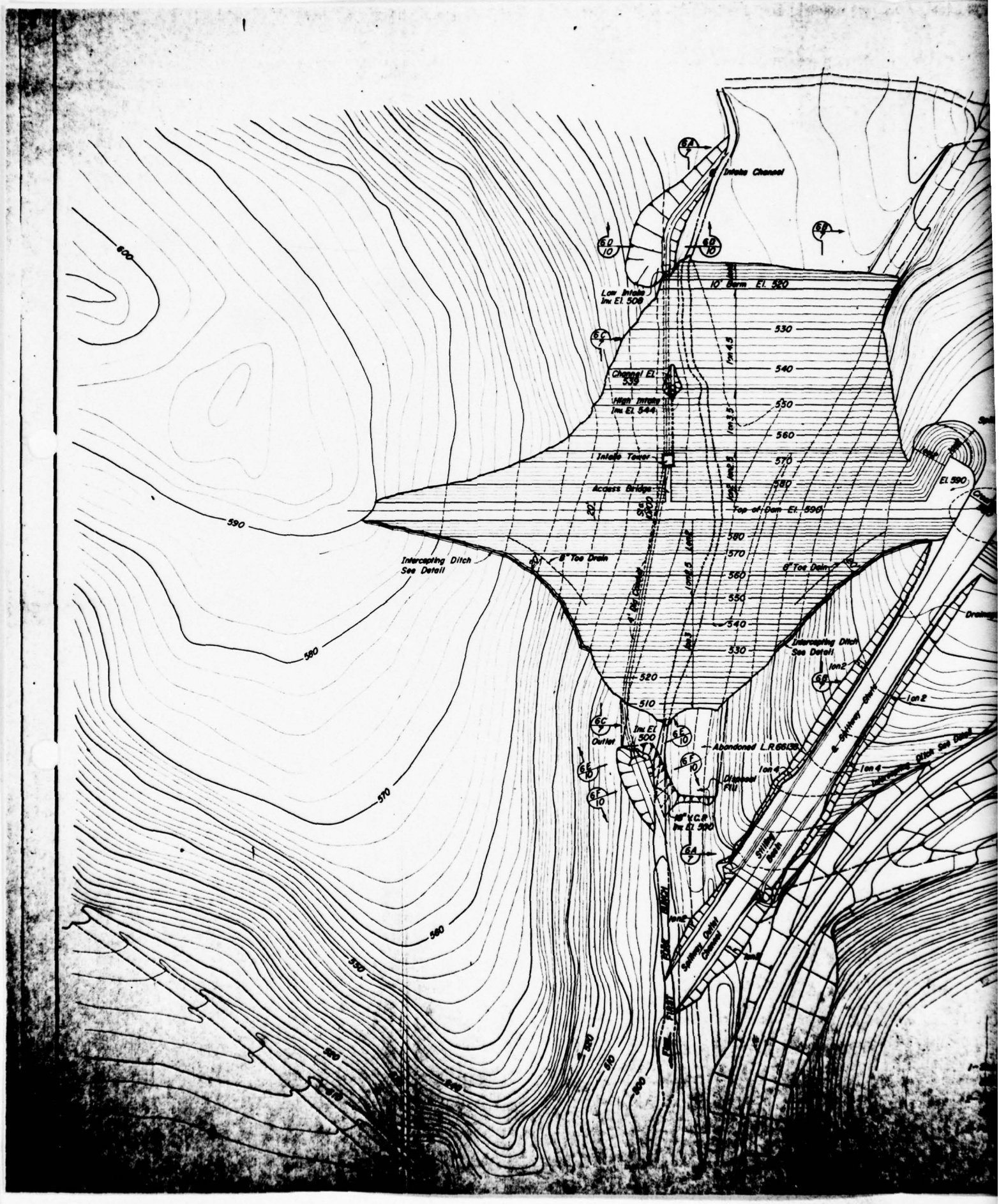
CONDUIT
WEIR

PLATE IV



RESERVOIR

PLATE V


Intake Channel
10' Berm El. 520
Low Intake Inv. El. 508
Channel El. 539
High Intake Inv. El. 544
Intake Tower
Access Bridge
Top of Dam El. 596
El. 590
Intercepting Ditch See Detail
8" Toe Drain
Inv. El. 500
Outlet
Abandoned L.R.66138
Channel Fill
48" C.M.P. Inv. El. 500
Spillway Crest
Spillway Outlet Channel
Intercepting Ditch See Detail
Drainage
600
590
580
570
560
550
540
530
520
510

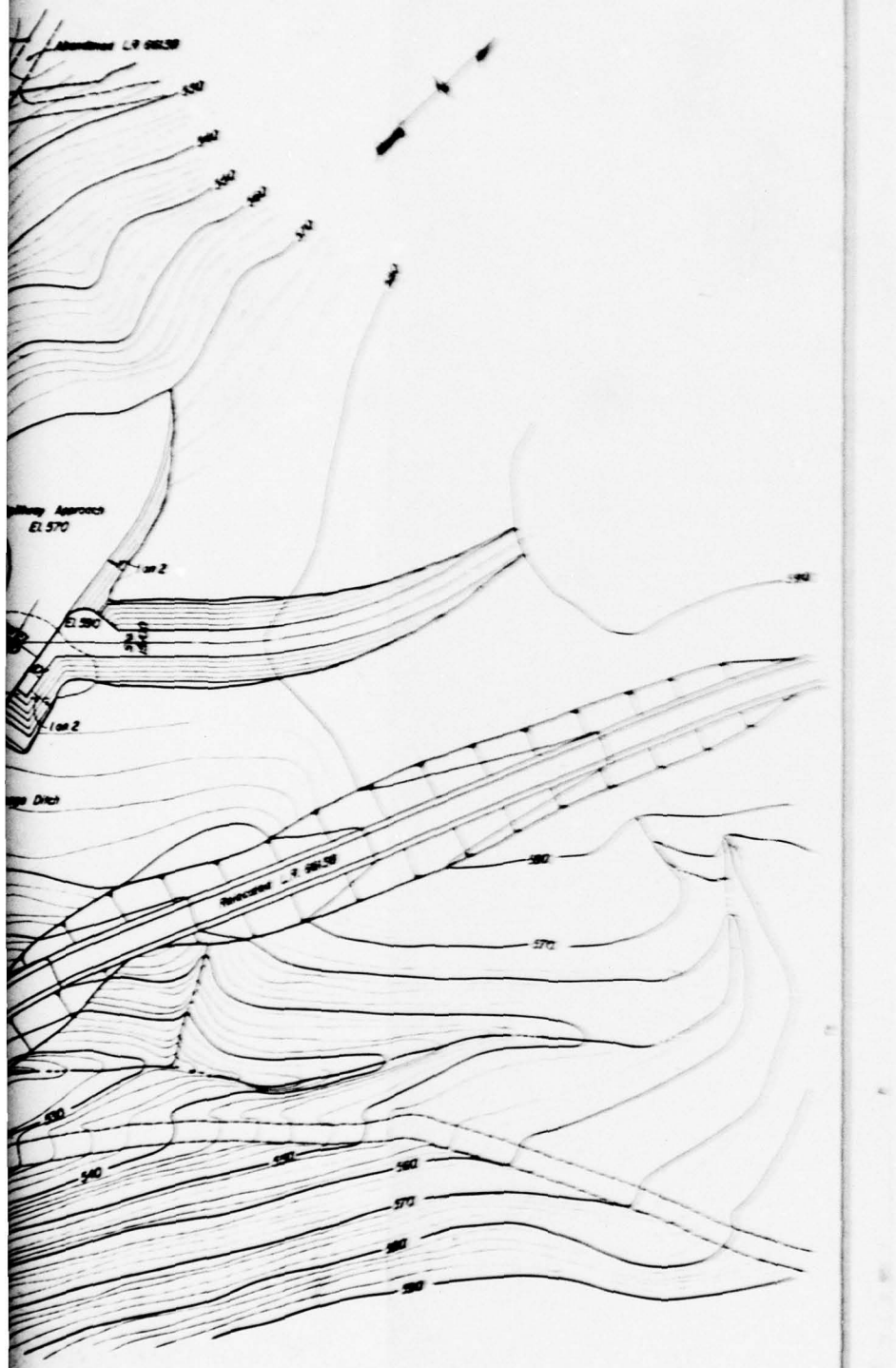
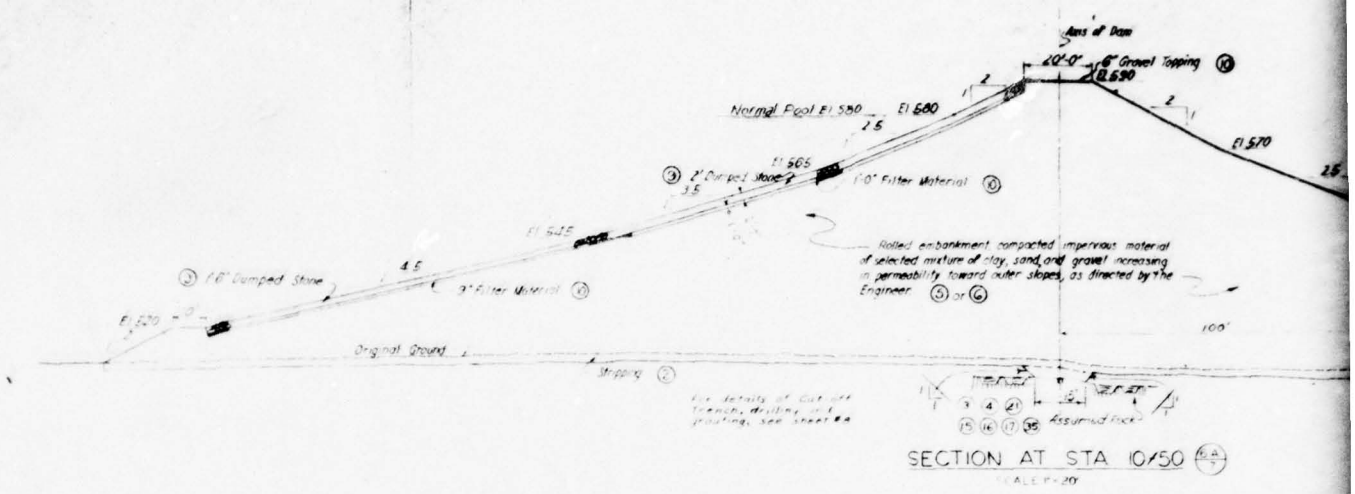


PLATE VI

GENERAL NOTES

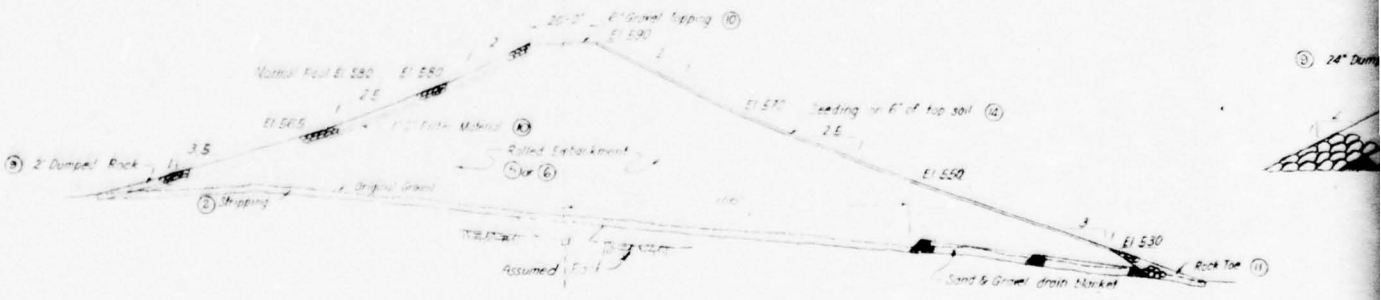
SCALE 1"=50'

P. H. GLATFELTER PROJECT
DAM AND RESERVOIR
GENERAL PLAN
P. H. GLATFELTER COMPANY
Spring Grove Pennsylvania
GANNETT FLEMING CORDDRY & CARPENTER, INC.
ENGINEERS



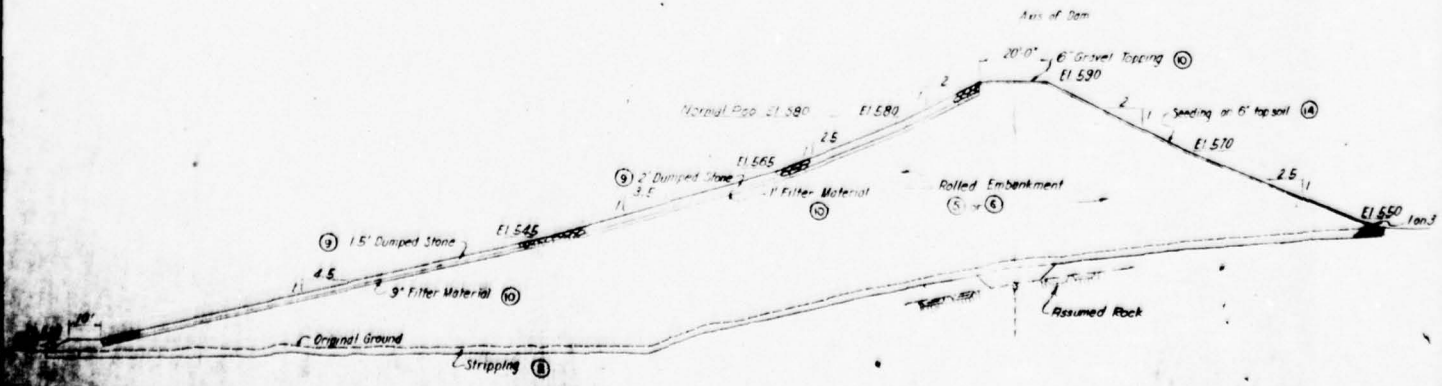
SECTION AT STA 10/50 (6A/7)

SCALE 1"=20'



SECTION AT STA 9/50 (6B/7)

SCALE 1"=20'

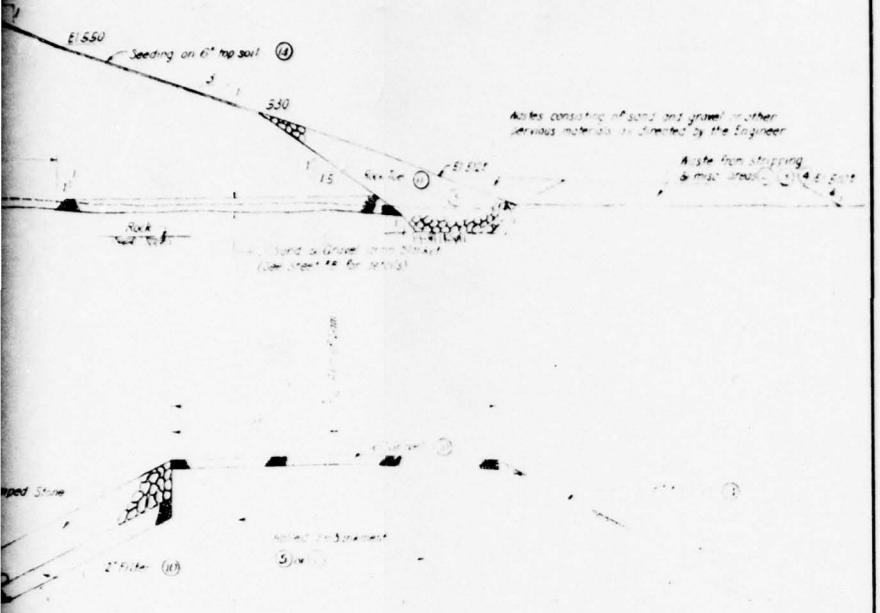


SECTION AT STA. 12/00 (6B/7)

SCALE 1"=20'

GENERAL NO

1- Section (6B) indicates Plan Sheet No. 6B



DETAIL - TOP OF DAM

SCALE 1/4" = 1'

PLATE VII

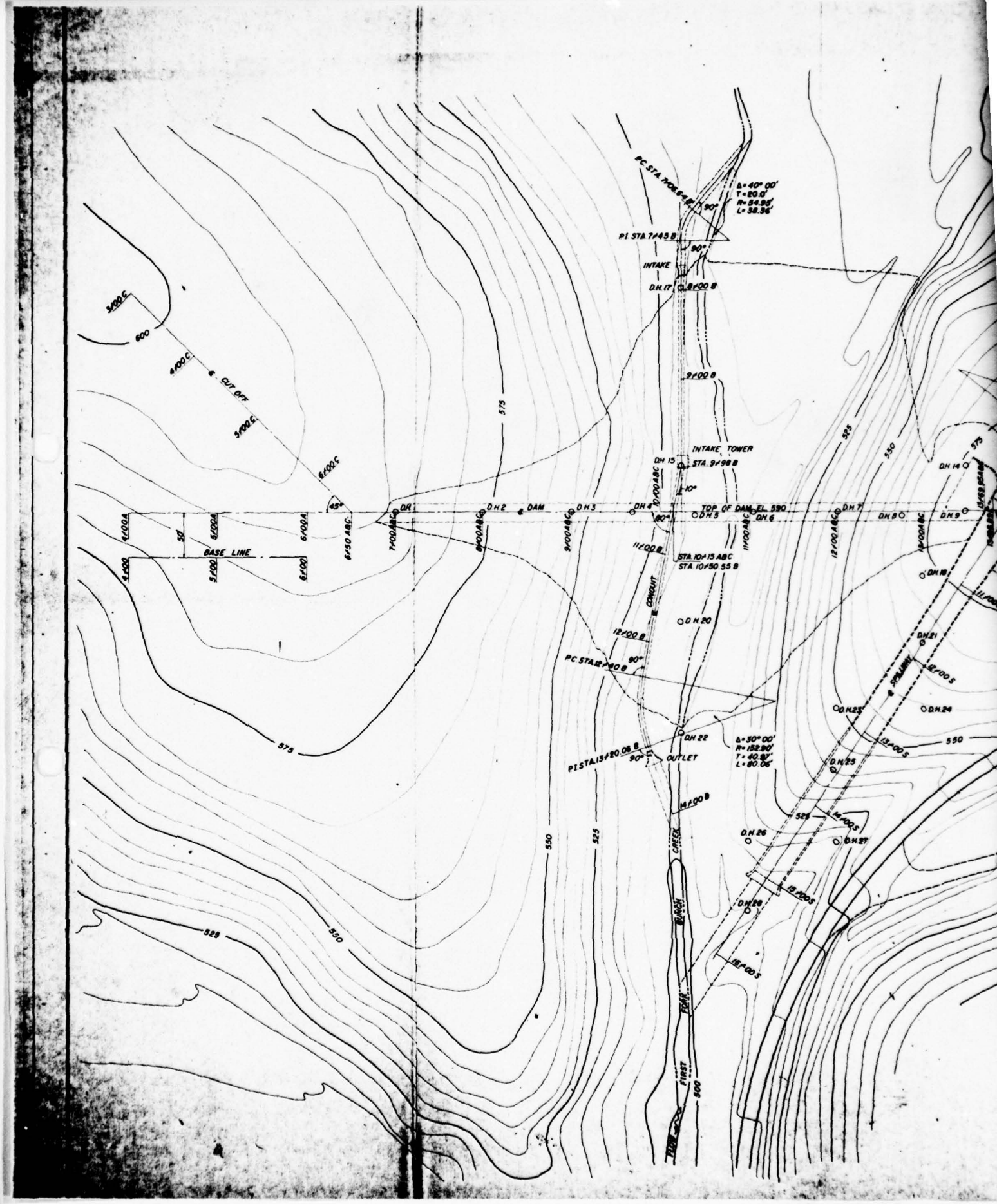
DESIGNED C.W.C.	P. H. GLATFELTER PROJECT	SHEET No. 7
TRACED W.L.D.	DAM AND RESERVOIR	
CHECKED C.Y.L.	First Fork Bunch Creek Pennsylvania	JOB No. 2420 D
APPROVED	EMBANKMENT Sections and Details	DATE APR. 1958
APPROVED	P. H. GLATFELTER COMPANY Spring Grove Pennsylvania	

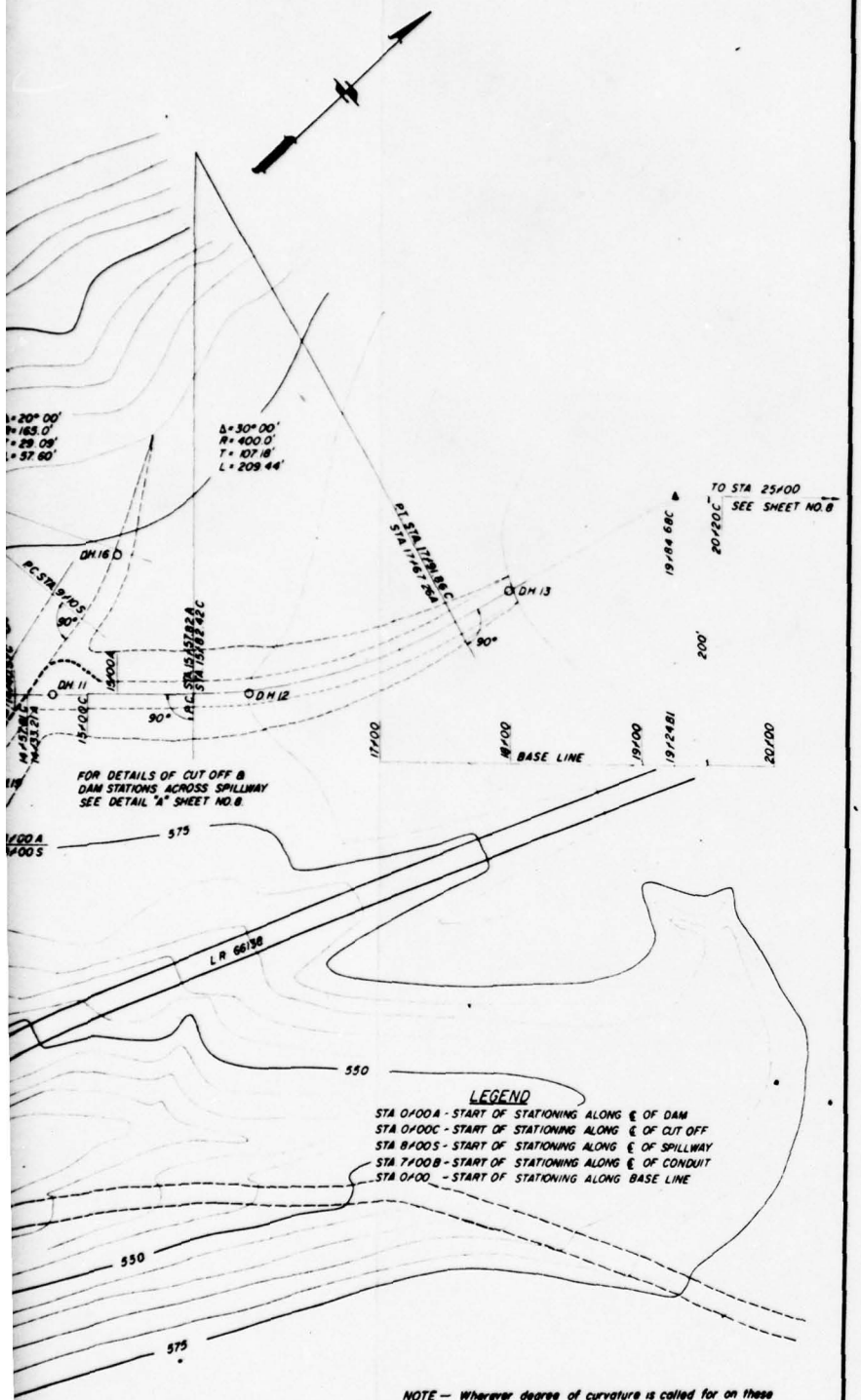
GARRETT FLEMING GODSBY & CARPENTER, INC.
ENGINEERS
606 N. SECOND ST. HARRISBURG, PENNA.

REVISIONS

NO.	DESCRIPTION	DATE	BY

...ings taken on Sheet
...mbers under which
...shall be checked
...ed site.
...has no suffix.


PC STA 7+06.6 B
Δ = 40° 00'
T = 20.0'
R = 54.95'
L = 38.36'
90°
P.I. STA 7+43 B
90°
INTAKE
D.H. 17
8+00 B
9+00 B
INTAKE TOWER
STA. 9+98 B
D.H. 15
10°
D.H. 14
4+00 C
5+00 C
CUT OFF
6+00 C
45°
575
525
550
600
D.H. 1
D.H. 2
℄ DAM
D.H. 3
D.H. 4
80°
TOP OF DAM EL. 590
D.H. 5
D.H. 6
D.H. 7
D.H. 8
D.H. 9
4+00 A
5+00 A
6+00 A
6+50 ABC
7+00 ABC
8+00 ABC
9+00 ABC
11+00 ABC
12+00 ABC
14+00 ABC
50'
BASE LINE
4+00 B
5+00 B
6+00 B
11+00 B
STA. 10+15 ABC
STA. 10+50 55 B
CONDUIT
D.H. 18
D.H. 20
D.H. 21
12+00 B
PC STA 12+40 B
90°
℄ SPILLWAY
12+00 S
D.H. 23
D.H. 24
D.H. 22
Δ = 30° 00'
R = 132.90'
T = 40.87'
L = 80.06'
P.I. STA 13+20.08 B
90°
OUTLET
D.H. 25
13+00 S
14+00 B
D.H. 26
D.H. 27
14+00 S
D.H. 28
15+00 S
16+00 S
BEECH FORK
FIRST FORK
500
525
550
575



LEGEND

STA 0+00 A - START OF STATIONING ALONG ℄ OF DAM
STA 0+00 C - START OF STATIONING ALONG ℄ OF CUT OFF
STA 8+00 S - START OF STATIONING ALONG ℄ OF SPILLWAY
STA 7+00 B - START OF STATIONING ALONG ℄ OF CONDUIT
STA 0+00 - START OF STATIONING ALONG BASE LINE

NOTE — Wherever degree of curvature is called for on these sheets, the arc definition is understood.

For logs of drill holes, see sheets 4 & 5

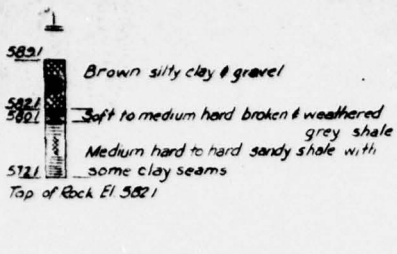
SCALE: 1" = 50'

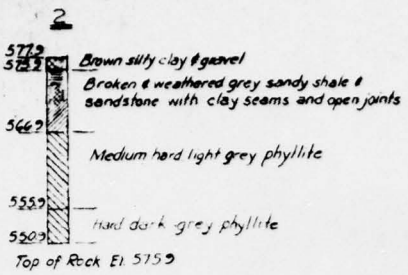
PLATE VIII

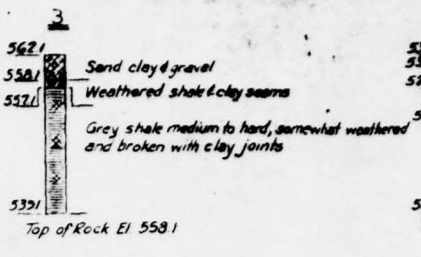
DRAWN WLO	P. H. GLATFELTER PROJECT	SHEET No. 3
T. ALCU WLO	DAM AND RESERVOIR	JOB No. 2420 D
CHECKED CYL	First Fork Bunch Creek Pennsylvania	
APPROVED	FOUNDATION EXPLORATION PLAN	DATE APRIL 1960
APPROVED	P. H. GLATFELTER COMPANY Spring Grove Pennsylvania	

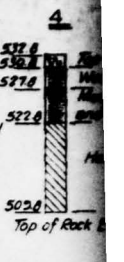
GANNETT FLEMING CORDDRY & CARPENTER, INC.
ENGINEERS
600 N SECOND ST HARRISBURG, PENNA

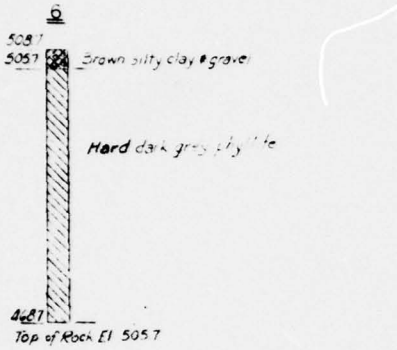
7

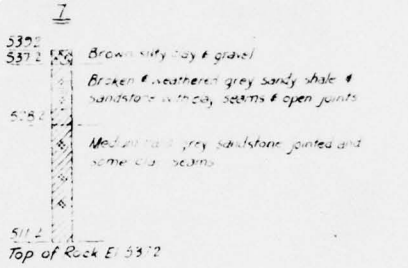


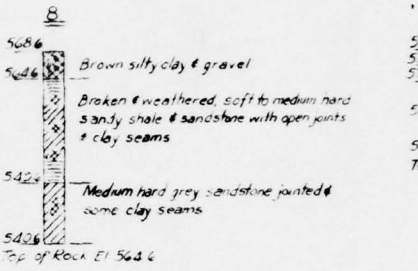


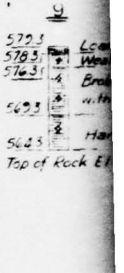


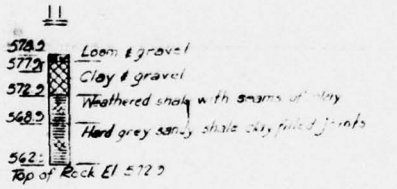


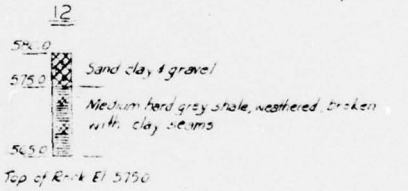


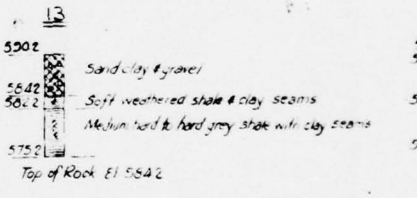


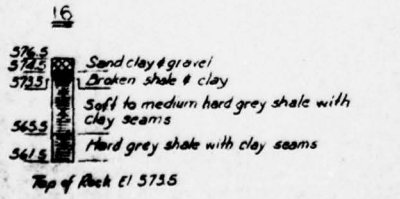


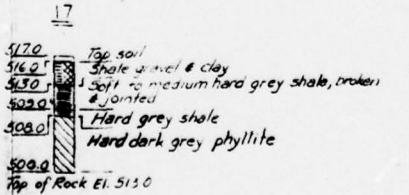


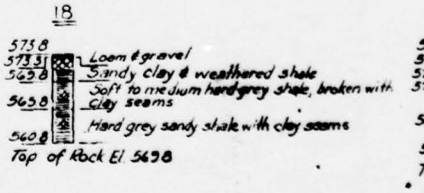












LEGEND

CLAY
SAND
GRAVEL
BROKEN ROCK
CONCRETE
SHALE
DISINTERGRATED SANDSTONE
PHYLLITE
SANDSTONE, SILTSTONE

5

511.0
5070 — Sand, clay & gravel
501.0 — Hard dark grey phyllite
Top of Rock El 507.0

...p soil & gravel
...Weathered shale & clay seams
...Medium hard grey shale, somewhat weathered
...and broken with clay joints

...Hard dark grey phyllite

...k El 530.8

10

...Loam & gravel
...Weathered shale with clay seams
...Broken & weathered hard grey, sandy, shale
...with clay seams

...Hard grey sandy shale, clay seams & joints
...k El 576.1

Top of Rock El 518.2

15

...Loam & decayed shale
...Soft weathered shale, broken and jointed
...with clay seams
...Medium hard to hard grey shale, broken and
...jointed with clay seams

...k El 575.6

Top of Rock El 510.8

20

...Loam & gravel
...Clay & gravel
...Shale & clay
...Weathered & broken grey shale with clay joints
...Broken & jointed hard grey sandy shale

...k El 571.6

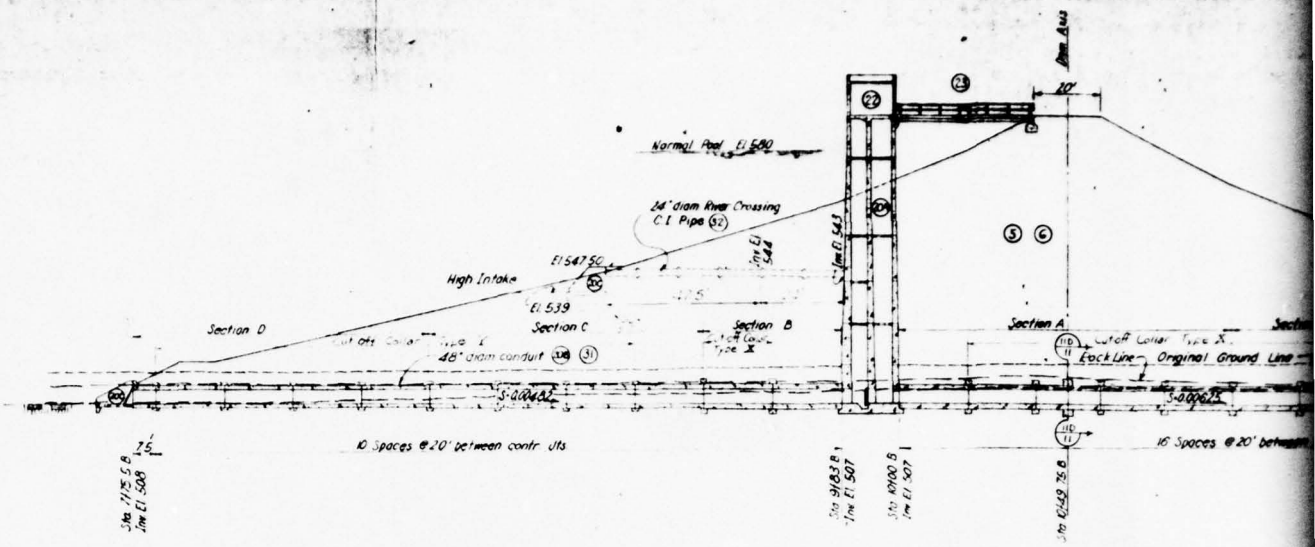
Top of Rock El 498.5

PLATE IX

DRAWN T.C.P.	P. H. GLATFELTER PROJECT	SHEET NO. 4
TRACED T.C.P.	DAM AND RESERVOIR	
CHECKED A.C.H.	First Fork Bunch Creek Pennsylvania	JOB NO. 2420D
APPROVED	FOUNDATION EXPLORATION LOGS-2	DATE APR 1968
	P. H. GLATFELTER COMPANY Spring Grove Pennsylvania	

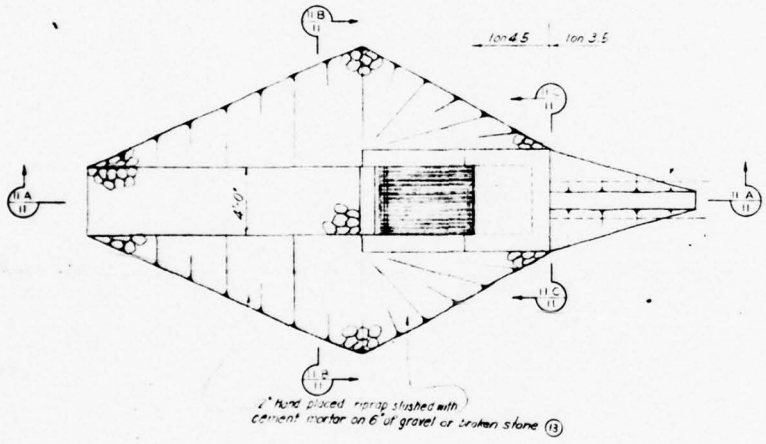
GARRETT FLEMING GOODSEY & CARPENTER, INC.
ENGINEERS
...N. SECOND ST. HARRISBURG, PENNA.

REVISIONS			
NO.	DESCRIPTION	DATE	BY



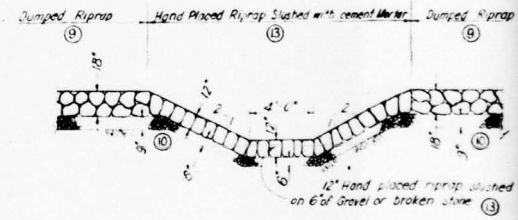
PROFILE ALONG ℄ CONDUIT

SCALE 1"=20'



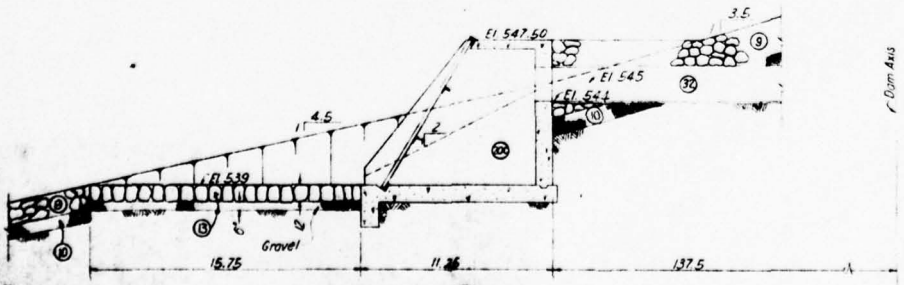
PLAN - HIGH INTAKE

SCALE 1/4"=1'-0"



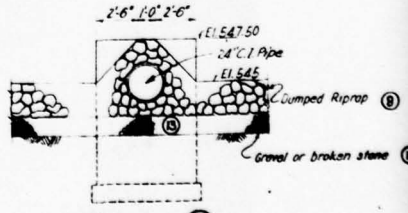
SECTION

SCALE 1/4"=1'-0"



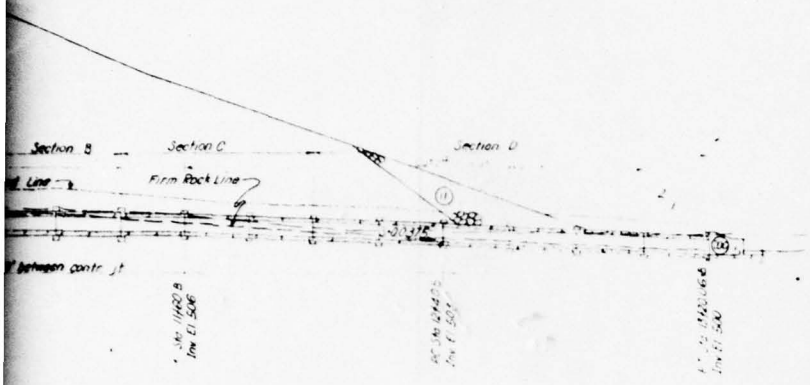
SECTION

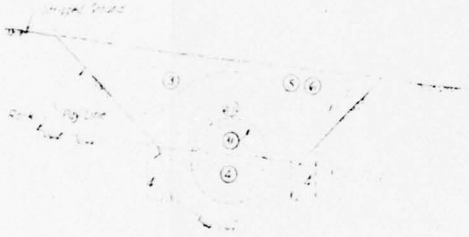
SCALE 1/4"=1'-0"



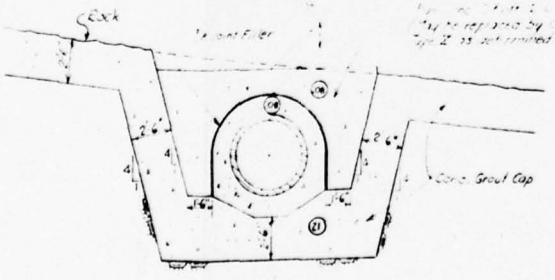
SECTION

SCALE 1/4"=1'-0"





TYPICAL SECTION
EXCAVATION FOR CONDUIT



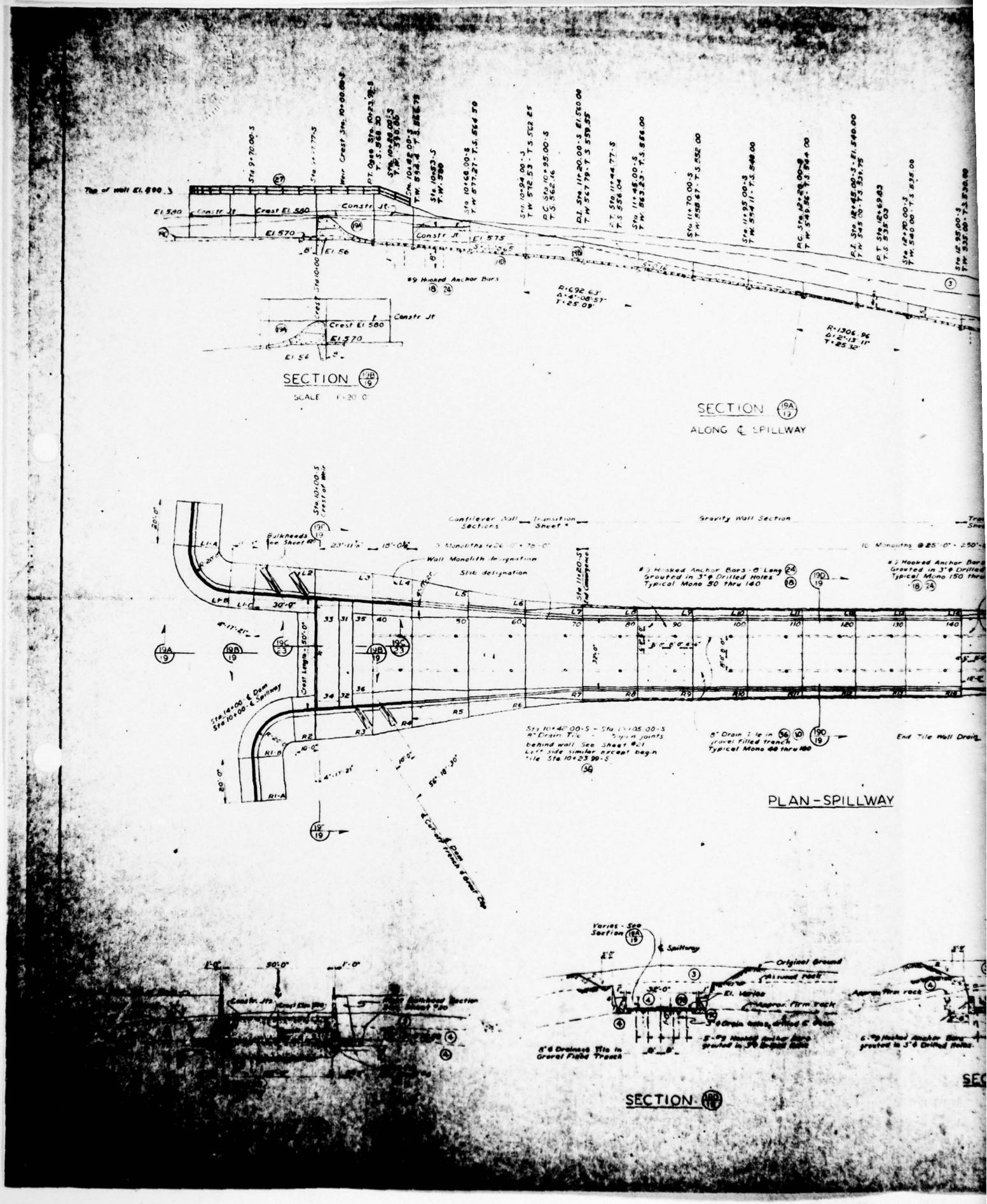
SECTION (10) (11)
SCALE: 1/4" = 1'-0"

PLATE X

NOTE: For General Notes pertaining to this sheet, see Sheet #9.

DRAWN C.Y.L.	P. H. GLATFELTER PROJECT	SHEET No.	11
TRACED W.L.G.	DAM AND RESERVOIR	JOB NO.	2420D
CHECKED C.Y.L.	First Fork Bunch Creek Pennsylvania		
APPROVED for Glatfelter	CONDUIT Profile and Sections	DATE	APR.1960
APPROVED for Barnett	P. H. GLATFELTER COMPANY Spring Grove Pennsylvania		

BARNETT FLEMING OSBERG & CARPENTER, INC.
ENGINEERS
600 N. SECOND ST. HARRISBURG, PENNA.


Top of wall El. 590
El. 540
Constr Jt
Crest El. 580
El. 570
El. 56
Crest Sta 10+00.00
Constr Jt
Crest El. 580
El. 570
El. 56
#9 Hooked Anchor Bars
SECTION
SCALE 1"=20'-0"
SECTION
ALONG ℄ SPILLWAY
Sta 10+00.00 Crest of Weir
Cantilever Wall Sections
Transition Sheet
Gravity Wall Section
Bulkheads See Sheet
Wall Monolith Designation
Slab designation
#3 Hooked Anchor Bars - 8' Long
Grouted in 3" ϕ Drilled Holes
Typical Mono 50 thru 140
Crest Length 500'-0"
Sta 14+00 ℄ Dam
Sta 10+00 ℄ Spillway
Sta 10+42.00-S - Sta 13+05.00-S
8" Ø Elgin Tile - Open joints
behind wall See Sheet #21
Left side similar except begin
Tile Sta 10+23.99-S
8" Drain Tile in gravel filled trench
Typical Mono 40 thru 130
End Tile Wall Drain
PLAN - SPILLWAY
Varies - See Section
℄ Spillway
Original Ground
Natural rock
El. Varies
Approx. firm rock
8"ϕ Drain tile in gravel filled trench
8"ϕ Drainage Tile in Gravel Filled Trench
SECTION

874

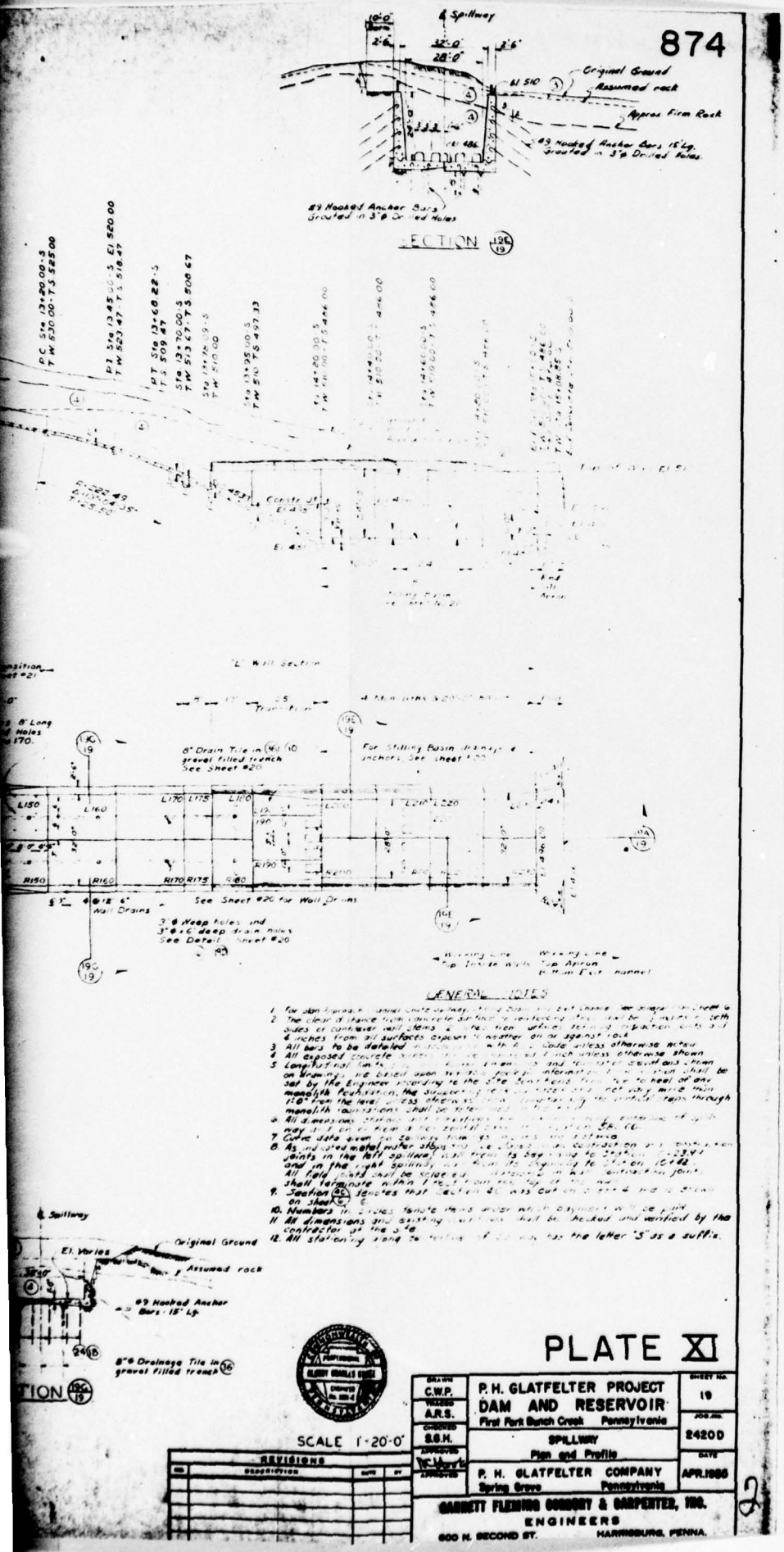
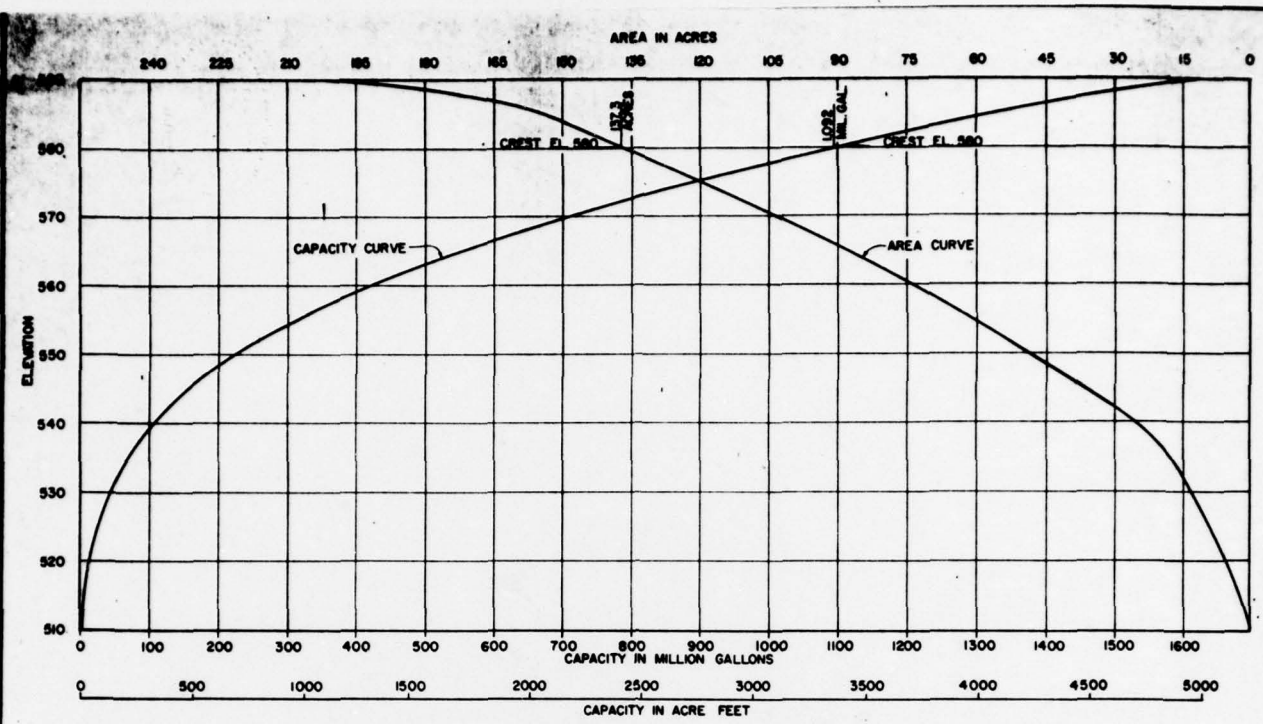


PLATE XI

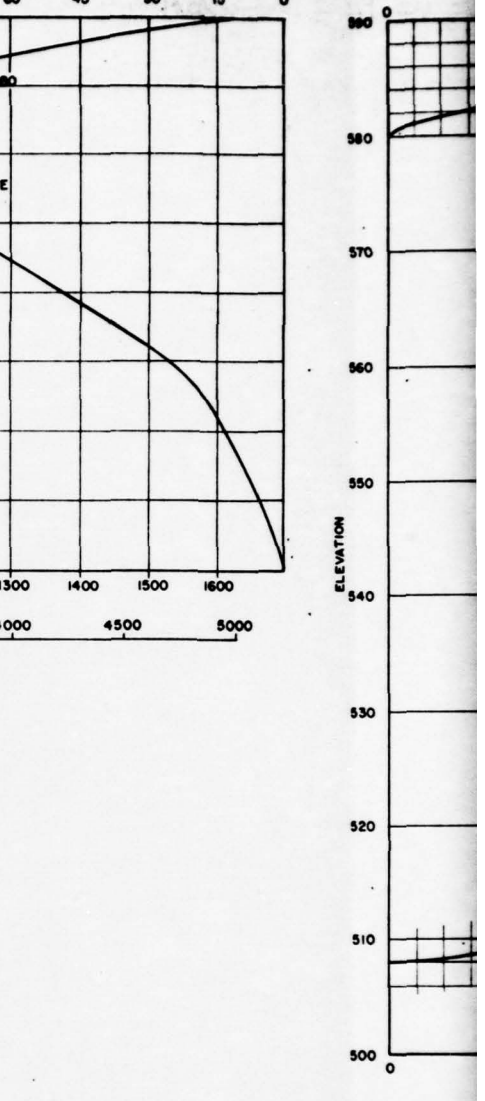
DESIGNED C.W.P.	P. H. GLATFELTER PROJECT	SHEET NO. 19
TRACED A.R.S.	DAM AND RESERVOIR	
CHECKED S.G.H.	First Fork Bunch Creek Pennsylvania	JOB NO. 2420D
APPROVED	SPILLWAY	DATE
APPROVED	Plan and Profile	APR. 1966
	P. H. GLATFELTER COMPANY Spring Grove Pennsylvania	

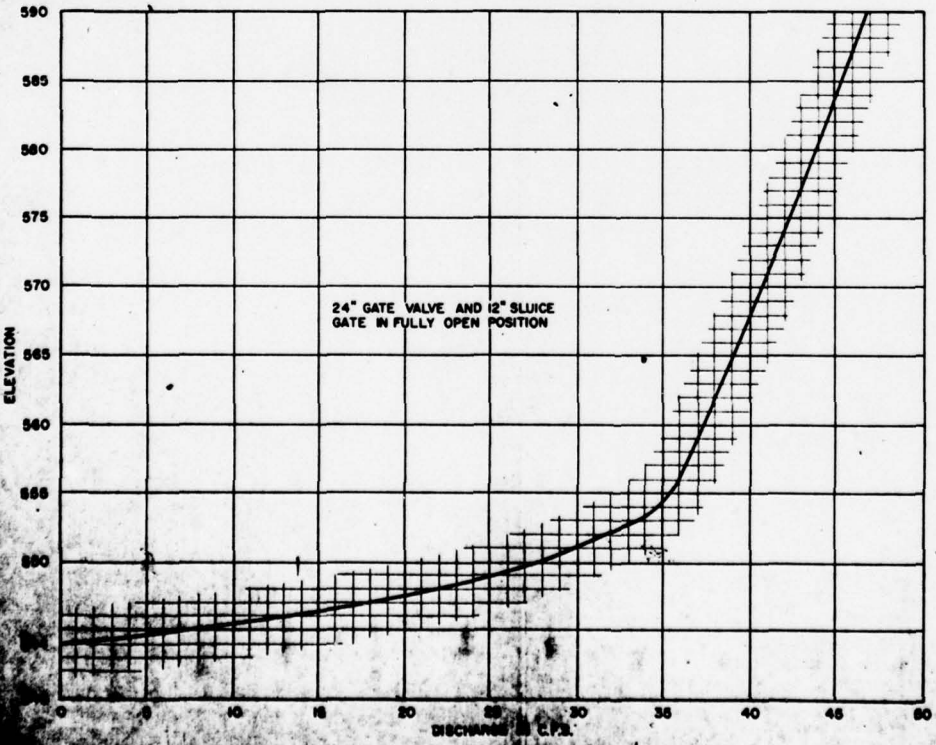
GARRETT FLEMING GODDARD & CARPENTER, INC.
ENGINEERS
600 N. SECOND ST. HARRISBURG, PENNA.

REVISIONS			
NO.	DESCRIPTION	DATE	BY

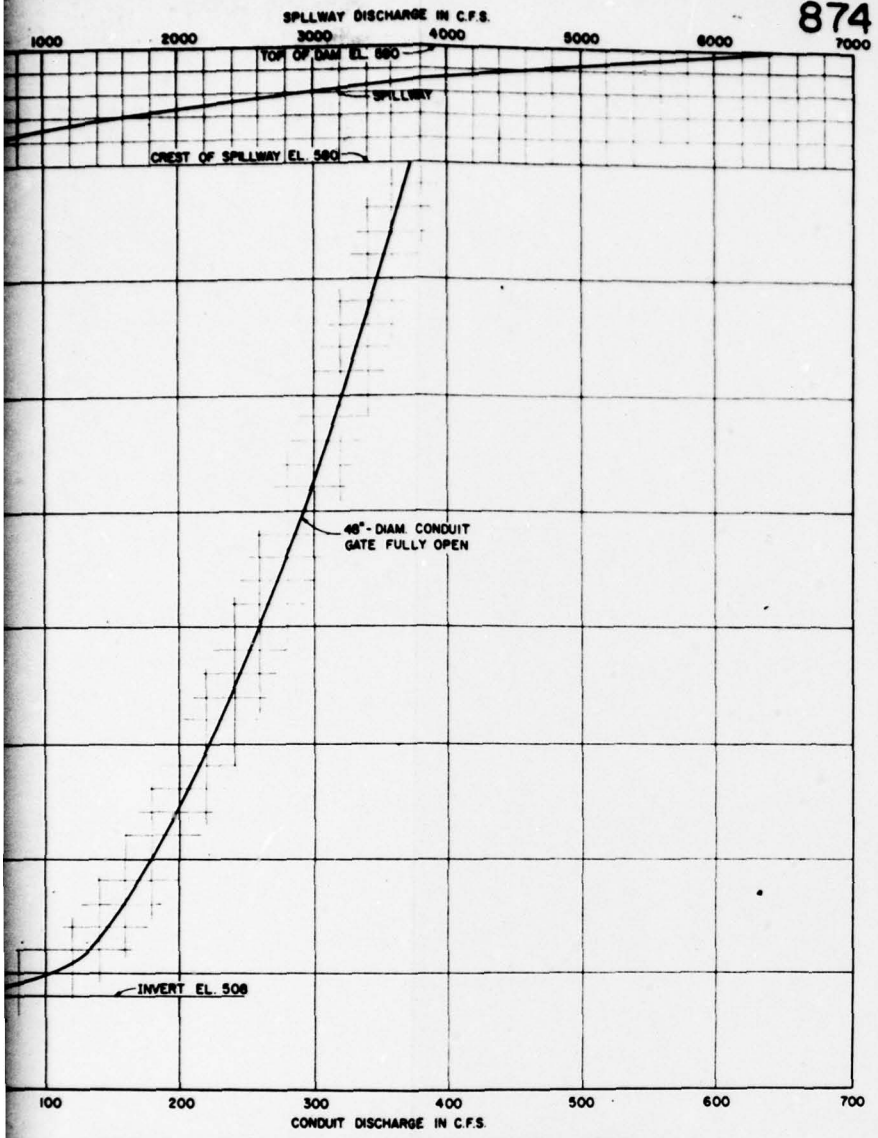


AREA & CAPACITY CURVES





RATING CURVE [illegible] INTAKE



RATING CURVE FOR SPILLWAY & OUTLET CONDUIT

PLATE XII

Drawn WLO Traced WLO Checked CVL Approved	P. H. GLATFELTER PROJECT DAM AND RESERVOIR First Fork Bunch Creek Pennsylvania RATING AND CAPACITY CURVES P. H. GLATFELTER COMPANY Spring Grove Pennsylvania	Sheet No. 2 Job No. 2420 D Date APRIL 1958

BARNETT FLEMING CORDRY & CARPENTER, INC.
ENGINEERS
HARRISBURG, PENNA.

APPENDIX E

Engineering Report on Leakage - 1958

Typical Weir Readings - 1960, 1963, 1978

Selected Annual Inspection Reports - 1966, 1974
Regarding Settlement

STUDY OF SEEPAGE THROUGH PaHaGaCo DAM

1. INTRODUCTION

This study pertains to the nature and causes of outflow from drain pipes of PaHaGaCo Dam observed up to the time of writing this report and contains suggestions for possible course of action in the future.

PaHaGaCo Dam is located on the First Fork Bunch Creek, about 12 miles southwest of York, Pennsylvania. The dam and reservoir project is owned by P. H. Glatfelter Company and has been built (construction completed April 1956) as additional storage for their pulpwood plant located about 3 miles downstream of the dam. The plant has an intake reservoir on the West Branch of Codorus Creek, downstream of its confluence with Bunch Creek. PaHaGaCo, therefore, feeds the intake reservoir by gravity flow during dry periods. Pertinent data concerning the main features of the dam is summarized below:

(a) Embankment (rolled earth fill).

Maximum Height above Streambed	85 ft.
Maximum Length	1127 ft.
Maximum Base Width	513 ft.
Total Volume of Fill	190,000 cub. yds.

(b) Structures.

Spillway (Concrete lined) -	Width at Crest	50 ft.	
	Total Length	380 ft.	
Stilling Basin -	Width	28 ft.	
	length	132 ft.	
Outlet works -	Height of Intake Tower	98 ft.	
	Diameter of Concrete Conduit	4 ft.	(I.D.)
	Length of Conduit	545 ft.	

(c) Elevations (feet above mean sea level).

Top of dam -	590
Spillway Crest -	580
Water Supply Pool -	580
Conduit Invert (at intake) -	508
River Surface (Mean level) -	508±
Lowest point in Streambed -	504±

(d) Drainage Area - 2.5 Sq. Miles

2. GENERAL GEOLOGY OF DAMSITE

The overburden in the area of damsite is residual soil resulting from the weathering of mostly metamorphosed sedimentary rock and generally consists of silty or clayey sands and gravel. The bedrock which outcrops at some places in the vicinity of the damsite consists of phyllite and metamorphosed sandstones and quartz. The depth of weathering is usually between 5 to 15 feet. The rock cores drilled in the vicinity of damsite indicate the presence of sound unfractured massive formation underlying the weathered zone.

A study of the geologic map of York County shows the presence of a fault line about 700 feet upstream of the dam axis and running generally parallel to it. This is a secondary fault from the Gnatstown Overthrust, which is found about a half mile farther to the north. It is a low angle fault dipping under the dam axis. No evidence of this fault was revealed in foundation drilling and grouting operations during construction. This indicated that the main fault was at a greater than 60 foot depth below the stream bed. There is a possibility of the existence of vertical joints or faults downstream of the axis of dam, which have their origin in the fault and are located in a plane normal to the fault. Faults in Southeastern Pennsylvania are generally gouge filled and not water bearing over large areas. However, they are known to be water bearing over localized areas and have their outlets in springs. It is very probable that the Raymond Myers and Albert Myers springs are outlets along the main fault - and a line between them could possibly represent the location of the fault line.

3. FOUNDATION & EMBANKMENT FEATURES

The foundation soil beneath the embankment consists of 2 to 6 feet of overburden which is a mixture of gravel sand and silt and is underlain by bedrock. The upper few feet of the bedrock though weathered and fractured at places is generally quite firm for the embankment loading. The appurtenant structures are all based on firm rock, founded generally 5 to 15 feet below top of weathered rock.

The embankment is an unzoned impervious rolled earth fill and except for small portion consisting of downstream rock toe, is made up of compacted soil - gravelly sandy silt and clayey sand. The upstream and downstream slopes vary as shown on the attached sketch. The downstream slope, except for the rock toe, is seeded up to the top of dam. A 3-foot filter blanket is provided on the downstream approximately between stations 9+50 and 11+50 starting at a distance 100 feet downstream of the dam axis. An 18-inch diameter pipe is installed approximately at the center of the rock toe, in the former stream bed, to drain out seepage water. A positive cut-off trench was excavated to bedrock,

pressure grouted by stage grouting methods by means of NX and EX holes on 3-foot centers to a depth of 60 feet, then backfilled with the same material as that used for the embankment. These holes only took a normal quantity of grouting material (about 0.5 bags per foot) indicating an absence of excessive voids in the bedrock.

4. OBSERVED SEEPAGE CONDITIONS

During conduit excavations in rock an unexpected artesian flow was encountered. To capture the flow of this water, two 8-inch diameter drain pipes, surrounded by filter material, were placed on either side of the conduit starting at points about 15 feet downstream of the dam axis and terminating at the downstream end of the conduit. Before the construction of the dam embankment, the 8-inch pipe on the right side of conduit (looking downstream) was flowing almost half-full while the drain pipe on the left side showed very little discharge. The water discharging from the two pipes was clear. Two lines of holes, one near the outlet works and the other near the spillway, were drilled on the upstream side at right angles to the dam axis. These were pressure grouted to arrest underseepage which might be generated due to conduit and spillway excavations. The grouting effectively sealed and dried up the upstream conduit excavation area. No seepage was noticed during spillway excavation. The presence of springs in the area generally located above elevation 570, attested to the existence of natural artesion conditions.

The time required for the reservoir pool to reach spillway crest elevation was estimated to be about two years under average creek discharge. However, since the reservoir was drawn down during the Summer of 1957 and the owners felt the need of sufficient additional storage on hand as soon as possible, water was pumped into PaHaGaCo from the main stream reservoir adjacent to the plant. The pumping was started in December, 1957 and stopped on May 2, 1958, when the pool level just touched the spillway crest elevation 580. During the last week of April 1958, when pool level exceeded approximate elevation 578, an observation of discharge from the drain pipes was made. This discharge was much greater than that noticed during an inspection made in June, 1957 when the reservoir level was just below elevation 570. In addition, it was noticed that the right side 8-inch pipe, which had been flowing almost half full, had much less discharge; while the left pipe was flowing full with considerable force although previously very little water was flowing out of it. The total combined discharge from the three drain pipes (two 8-inch pipes and one 18-inch pipe) was considered to be about 1.2 mgd, as estimated by the flow of water over a temporary weir constructed downstream of the three drainpipes. The discharge from the 18-inch pipe was roughly estimated to be half of the total combined discharge. The water from all the drain pipes was clear and

sediment free. An inspection made on May 13, 1958, when the reservoir pool was in excess of elevation 580 (spillway crest), showed that the seepage conditions were unchanged.

5. SEEPAGE COMPUTATION

In order to account for the total discharge from the three drain pipes, computations for the maximum possible seepage through the embankment were made by assuming extreme conditions of permeability for the maximum embankment section. The permeability coefficient of the compacted impervious fill was estimated at the highest possible value of 180×10^{-6} cm/sec (almost 60 times the average laboratory determinations) and is based on 20 per cent size selected from an average gradation curve for the soil. Furthermore, a ratio of 9 was assumed for horizontal to vertical permeability. With these values, the seepage for a maximum head of 80 feet for a 400-ft effective length of the embankment was computed to be 330,000 gal/day. Seepage through foundation overburden was combined with that through embankment because, the foundation overburden is generally very shallow (2 to 6 feet thick) and its soil characteristics are very similar to those of the embankment. Hence, the discharge as observed at present does not seem to be wholly due to seepage through the embankment.

6. CONCLUSIONS

Since the seepage water is being controlled by the drainage system and is quite clear, there is no danger of piping or of any harmful effects upon the dam structure. The loss of approximately 1.85 c.f.s. in drainage flow from a reservoir of PaHaGaCo depth and capacity (approximately 76 foot water depth with capacity of 1.1 billion gallon) would not ordinarily be considered to be excessive. In this case, due to the small drainage area and the need to conserve the water, it is desirable to hold any losses from the reservoir to a minimum, if it is possible to economically reduce the seepage flow.

Seepage through the embankment cannot account for the total drainage discharge. Not over half of the total discharge, probably that issuing from the 18-inch pipe is considered to be embankment seepage. The remaining flow is probably due to seepage flow through joints and crevices in the underlying rock, downstream of the grouted cut-off. A portion of this flow undoubtedly originates in the hillside downstream of the axis of dam - since there was flow from the right pipe and right hillside before any water was stored in the reservoir. The remaining flow probably originates in the reservoir, either by raising of the general water table by prolonged water storage, or by the charging of springs on the upstream side of the dam. Such charging would be indicated by a sudden increase or decrease in quantity of drainage flow

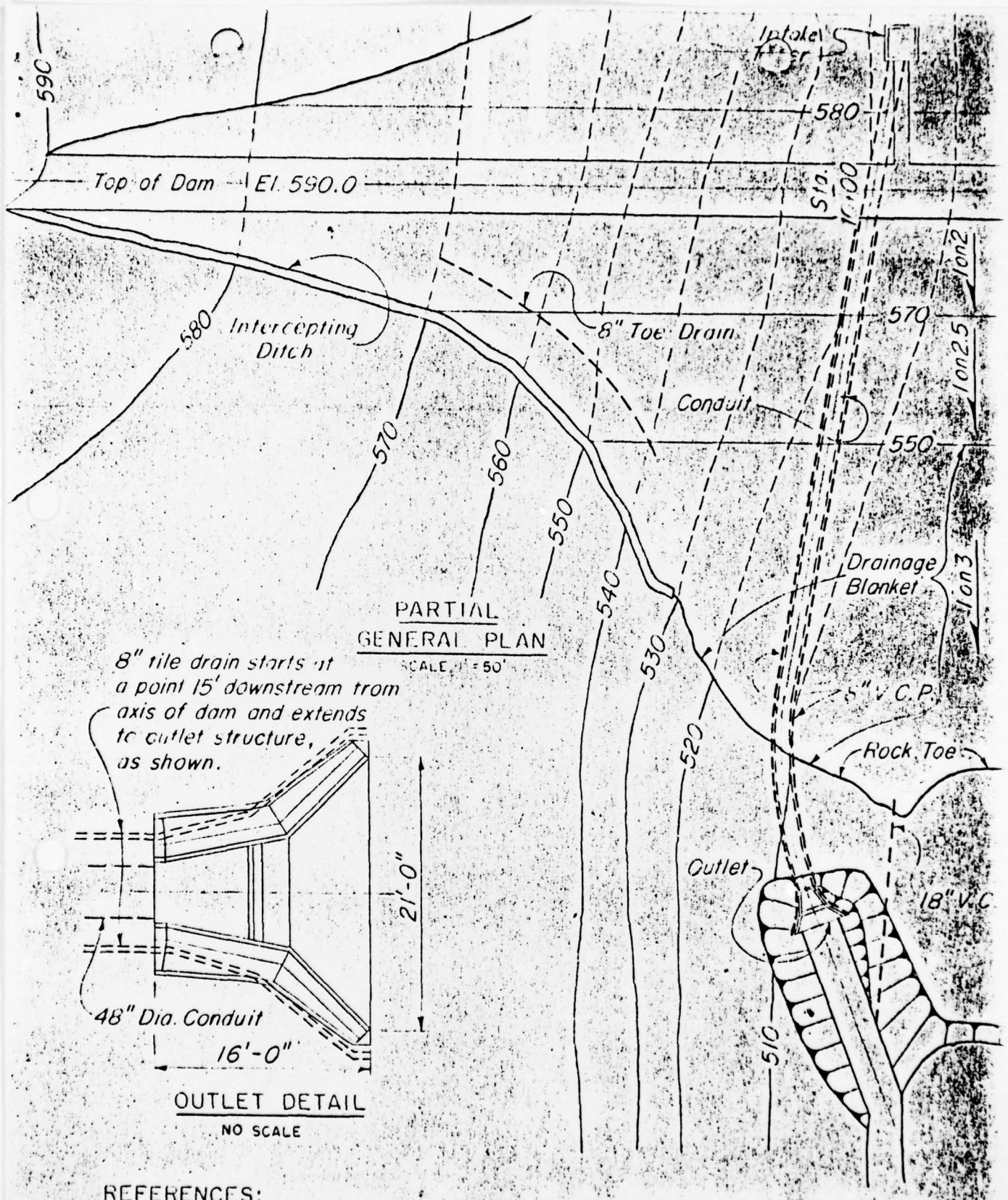
when the reservoir pool elevation was above or below the elevation of the springs.

Before any unduly expensive remedial measures are taken, it is considered feasible to simply watch, observe and record the pool - drainage discharge relationship. Drilling and grouting is an expensive operation and, unless there is reasonable assurance that it will be effective, it can be extremely wasteful.

A. C. Hooke

Gannett Fleming Corddry
and Carpenter, Inc.

6/11/58



REFERENCES:
Sheets 6 and 10 of As Built Contract Drawings.

P. H. GLATFELTER PROJECT

EMBANKMENT DRAINAGE

GANNETT, FLEMING CORDDRY & CARPENTER, IN
HARRISBURG, PA APRIL, 19

ACTION TO: B. C. MILLER

Info to: A. J. Luettgen
G. H. Glatfelter
N. B. Rohrbaugh (6)
H. L. Warner

FROM: J. A. Roth

July 18, 1960

SUBJ: Lake Pahagaco Dam Leakage

Date	Dam Level Inches	In. Over 6 Ft. Weir	Gallons/Minute	Gallons/Day
6/10/60	full	1 1/2	396	570,240
17	full	1 1/4	301	433,440
24	full	*		

* Weir washed out, no reading available.

Date	8 in. drain on right side of drain valve facing south	8 in. drain on left side of drain valve facing south	18 in. drain on left side of drain valve facing south	Lake Surface
6/10/60	55°F	61°F	64°F	73°F
17	52°F	62°F	65°F	71°F
24	55°F	65°F	67°F	75°F

J. A. Roth

/js

February 19, 1963

ACTION TO: B. C. MILLER

Info To:
P. H. Glatfelter III
J. R. Atwater
G. H. Glatfelter
N. B. Rohrbaugh (6)
H. L. Warner
R. O. Brooks

FROM: J. A. Roth

SUBJECT: Reservoir Leakage Data - February 18, 1963

	Dam Level Inches	Leakage Gallons/Minute	Leakage Gallons/Day
Lake Lehman	Full	42	60,480
Lake PaHaGaCo	Full	142	204,480

Lake PaHaGaCo Breakdown:

8" drain on right side of drain valve facing South - 7 gpm.
8" drain on left side of drain valve facing South - 100 gpm.
18" drain on left side of drain valve facing South - 35 gpm.

JAR:rls

May 10, 1978

MEMO TO:	P. H. Glatfelter III	C. N. Carter
	T. C. Morris	L. R. Metzger
	G. H. Glatfelter	J. A. Roth
	B. C. Miller	R. R. Rabenstine
	P. H. Hershey	J. W. Williams
	H. J. Fuller	

FROM: D. E. Hoover/C. F. Myers

SUBJECT: Inspection of Water Reservoir Dams

The inspection of Lake PaHaGaCo was made on May 1, while all other areas were inspected on April 27, 1978. The last measureable rainfall was 0.51 inch on April 20.

(More)

Lake PaHaGaCo Dam

Dam was full and overflowing. No water was being released from the valve and no water was leaking through the valve. The following measurements were made at the seepage weirs.

		1975	1977	1978
Facing Dam:	8" Right Side	5/8" or 17 GPM	3/4" or 23 GPM	1/4" or 6
	8" Left Side	Trace	Leaking Around	1/2" or 13

10" - The ten inch weir had 1 1/8" or 35 GPM flow. This was not measured on previous inspections.

Concrete walls and spillway are in excellent condition except for the items mentioned under maintenance.

The control tower and outlet structures are in good condition.

The north corner of the first flat panel on the east wall looking from the west wall of spillway is chipped at the water line, but is no worse than last year. Keep watching.

Five medium and three little cedar trees are growing on dam breast.

Maintenance items include:

1. Paint control tower door frame and door, inside and outside.
2. Tar cracks at key wall on east spillway wall, second section past handrail, both North and South ends.
3. Remove bush growing against east spillway wall at second section past handrail.
4. Remove rocks from drainage ditch along east side of spillway.

November 11, 1966

INFO TO: C. H. Glatfelter
B. C. Miller

FROM: N. B. Rohrbaugh

SUBJECT: Inspection of Water Reservoir Dams

On November 11, 1966 the PNGCC water reservoirs, dams, and spillways were inspected.

LAKE PAHAGACO RESERVOIR

The ogee, ogee side walls, spillway and spillway walls are all in good condition. Hot bituminous material should be poured into the top of the spillway sidewall joints.

The embankment top has settled on the reservoir side. The 3/4" stone should be removed and run size stone placed to restore to the original height and then 3/4" stone added to restore the original level.

The door and door-frame in the control house should be cleaned, caulked and painted. The joint between the walkway, and the control house should be resealed with hot asphalt.

The above restoring of the embankment is estimated at $8,000.00 and should be in the Capital Budget for 1967.

October 30, 1974

INFO TO: G. H. Glatfelter
B. C. Miller
P. H. Hershey
D. E. Hoover
C. N. Carter
J. W. Williams
R. O. Brooks
L. R. Metzger

FROM: N. B. Rohrbaugh

SUBJECT: Inspection of Water Reservoir Dams

Lake PaHaGaCo Dam

All the concrete walls and spillway are in excellent condition. The crushed stone on east side of spillway breast has been replenished to original level. The control tower and outlet structure are in good condition.

The settlement of the upstream edge of the main embankment has been rebuilt and restored to its original condition.

Work to be done:

1. Stones should be removed from the east side of spillway concrete drainage gutter also on west side near stilling pond.

2. Joint sealer should be applied to all the joints at top of spillway walls.

3. ~~Two~~ ground hog holes should be sealed. They are about 6 feet apart approximately 50 feet west of spillway ~~near~~ top of embankment.